# The Engineer

OCTOBER 18, 1957 | 28 ESSEX ST., STRAND, LONDON, W.C.2 | TWO SHILLINGS



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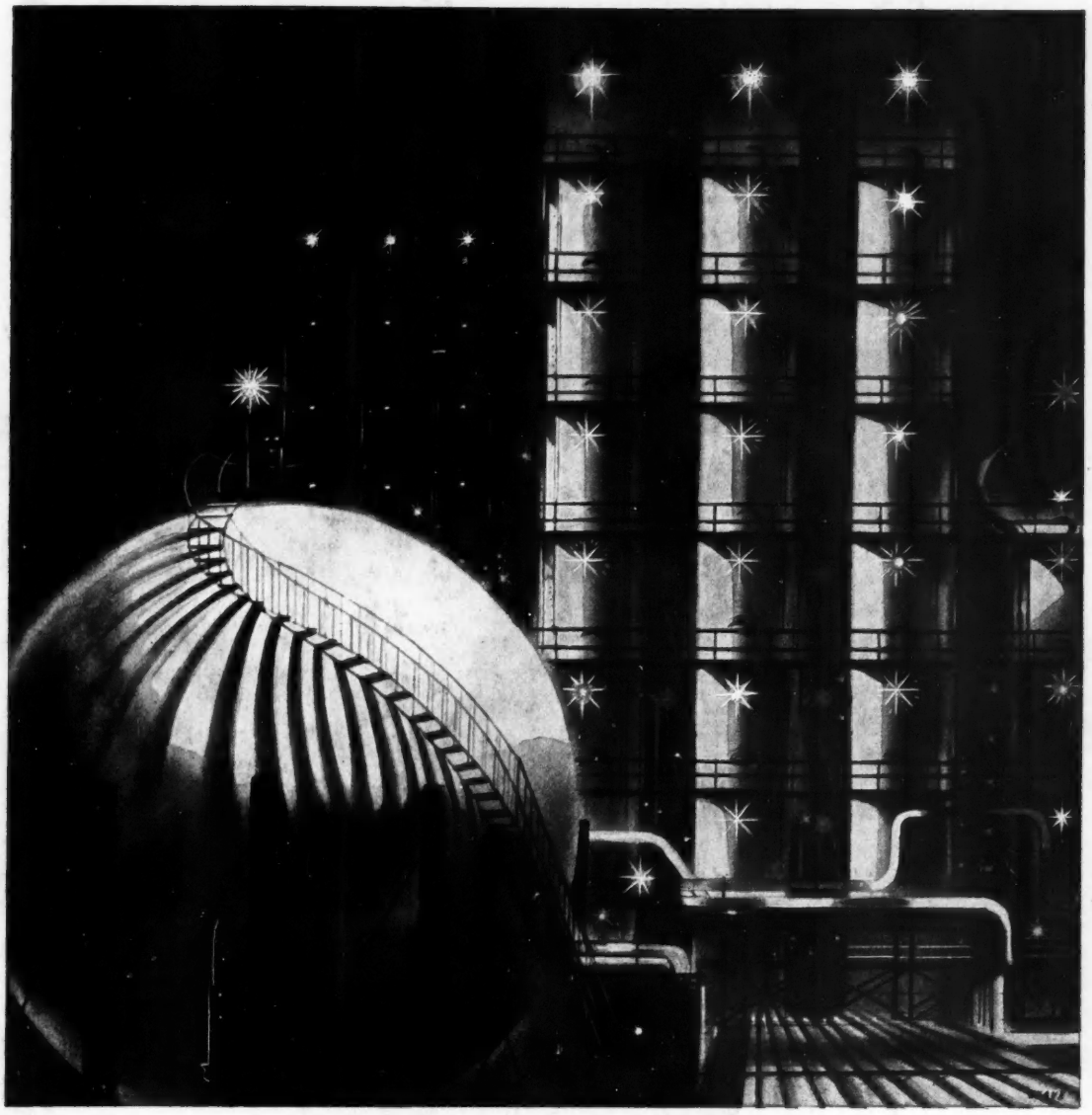


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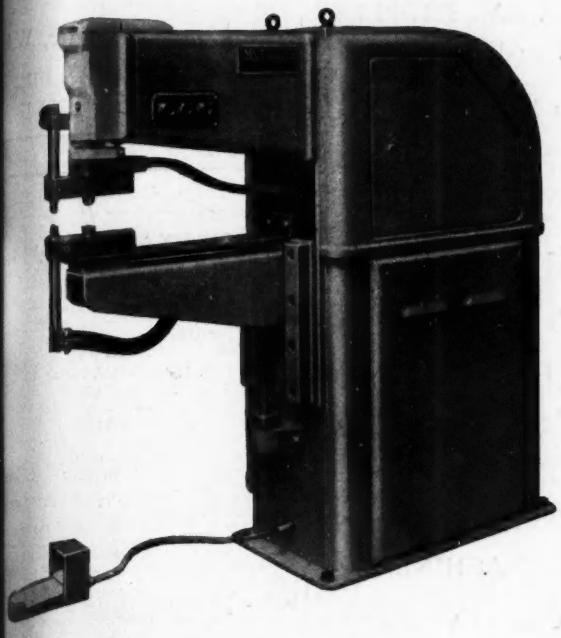

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# THE ENGINEER

*ESTABLISHED* 1856

28 ESSEX STREET, STRAND, LONDON, W.C.2.

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E. R.

*By Order of the Minister of Supply*

## GOVERNMENT SURPLUS STORES

AUCTION PROGRAMME

| | | *Main Location* | *Auctioneers* |
|---|---|---|---|
| October 22 | **600 Vehicles**, including Foden, Dennis & Scammell Diesels, A.E.C. Tractors, Trucks, Motor cycles trailers, &c. | 61 B.V.D., Georgetown, and 62 B.V.D., Irvine. (Sale at Glasgow.) | DIXON & WALLACE, LTD. (Dept. L), Bank Buildings, Graham Sq., Glasgow, E.1. (Tel.: Bridgeton 2447.) |
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| | | | |
|---|---|---|---|
| November 1 | **Miscellaneous stores**, including:— | Returned Stores Depot, Reed Hall, Colchester, Essex | FENN, WRIGHT & CO. (Dept. L), 146, High Street, Colchester, Essex. (Tel.: 3171.) |

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| | | | |
|---|---|---|---|
| November 6 | **Miscellaneous stores**, including scrap canvas furniture and M.T. spares | Northern Command Ordnance Sub-Depot, Barlow, Nr. Selby, Yorkshire | BARTLE & SON (Dept. L), 50–52, Merrion St., Leeds, 2. (Tel.: 2–0898.) |
| November 11–15 | **Vehicles** | M.O.S. Storage Depot, Ruddington, Notts. | WALKER, WALTON & HANSON (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.) |
| November 14 | **Miscellaneous stores** | Returned Stores Depot, British Railway Sidings, Colley Lane, Bridgwater. (Sale at Royal Clarence Hotel.) | J. H. PALMER & SONS (Dept. L), Bank Chambers, Burnham on Sea, Somerset. (Tel.: 2326.) |

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# THE ENGINEER

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## THE ROCKET FIRING SUBMARINE

General Keightley's recently published report on the Port Said operations must have made good reading for the Soviet leaders. Mr. Khrushchev is determined that, in arms, Russia should surpass the production of the United States and the Western Powers by 1965. He appears equally resolved that the Middle East and other uncommitted nations should be brought under Soviet influence by providing them with arms and economic aid and stirring up subversive movements in those countries. Hence the anxiety of the Soviet leaders to emphasise Russia's readiness for nuclear war. The establishment of the Russian artificial satellite in its orbit may have been timed to emphasise that point as much as to contribute to the scientific work of the International Geophysical Year. The more often, and the more emphatically, the point is emphasised, the more likely are the United States and Britain to expend their resources in building up expensive weapons which Mr. Khrushchev believes will never be used. Equally they will have less to spend on conventional forces. Britain has already fallen a victim. Since the advent of the megaton bomb in 1954 we have not only been spending much more on defence than we can afford but our conventional forces have had to be much reduced to ensure priority for " the deterrent." General Keightley had three months to prepare for a probable emergency in the Middle East. With an insufficient number of aeroplanes to transport an airborne brigade group from Malta and with no tank landing ships available to form part of the British naval forces in the area, he required ten days' notice to occupy the focal points in the Suez Canal. In the result he could do nothing for five days but use straight wing naval aircraft from carriers to eliminate the Egyptian air force and bomb military targets. Unfortunately, current defence planning seems to show that we have learnt nothing from the campaign. Indeed, our conventional forces are to be halved to enable more of our scanty resources to be allocated to " the deterrent." Mr. Khrushchev must be delighted, and he is now trying to frighten the United States with an intercontinental rocket, using the existence of the satellite as proof of its existence.

Yet the existence of the satellite does not prove that Soviet scientists and engineers have been able to overcome the problem which has hitherto baffled their Western colleagues—the tendency of available materials to burn up and disintegrate when the 5000-mile rocket re-enters the atmosphere. What is certain is that Soviet engineers are second to none in what has been achieved in the field of nuclear energy, and it seems far more likely that the Soviets have decided that submarines with atomic power plants provide the most effective launching vehicle for their intermediate range ballistic rocket. The conventional diesel-electric driven submarine can be —and several American submarines already are—equipped to launch guided flying bombs of the " Regulus " type, with a range of up to 500 miles. These missiles are 57ft long with a wing span of 20ft and look like a swept-wing jet fighter. It would be wise to assume that many existing Soviet submarines are similarly equipped. But a 500-mile range is insufficient for missiles to be launched against Britain from the Arctic or other relatively safe waters, or to reach the United States centres of industry when fired from positions 100 or 200 miles from the American coast. The Secretary of the U.S. Navy has, however, announced that one of the thirteen submarines with atomic power plants now on order—the " Nautilus " and " Sea Wolf " are already in commission—is being built specifically to launch missiles with a range of between 1200 and 1500 miles, which can mean nothing else than the intermediate range ballistic rocket. To launch a " Polaris " type rocket—a rocket about 70ft long and weighing over 50 tons, the naval version of the 1500-mile " Jupiter " and " Thor " —the submarine will have to be very large. The only disadvantage of a large submarine is that she presents an easier target for detection by asdic but it will be the aim of guided missile firing submarines to give asdic vessels a wide berth. Nor should they have any difficulty in doing so, with the aid of their own asdic and listening devices and—should they be on the surface—radar locators. Moreover, a submarine which, when detected, is able to move away at 25 knots in any direction and at any depth between 100ft and 1000ft will be an extremely difficult target to hunt and destroy.

If, then, the United States—which has surface command of the sea—considers it necessary to build large submarines of this kind, it may well be assumed that

Russia is doing likewise. Even the 800-mile ballistic rocket—and, according to N.A.T.O. intelligence, the Soviets have already a plentiful supply of these missiles—is a great improvement on the 500-mile guided flying bomb, which is no less liable than a piloted bomber to be shot down. It is, of course, less accurate, but, unlike the intercontinental rocket (25 per cent of which, according to Dr. Dornberger, would land not merely far from the target, but even in the wrong country !) the intermediate range missile should be sufficiently accurate to land in the target area. In this connection it is interesting to note that the U.S. Navy is now converting two merchant ships—one to carry out test launchings of the " Polaris " and the other to investigate a new inertial navigational system with which it is hoped to fix the position with pinpoint accuracy of the missile firing ship. No authoritative details of the system—which has been developed by the marine division of the Sperry Gyroscope Company—have yet been announced, but it is designed to give the precise location of the firing ship in relation to the target, the true vertical, and the true north.

### LANGUAGE AND TECHNICAL PUBLICITY

Much has lately been spoken and written on the subject of the teaching of English to engineers and on the importance of ensuring that all technical writing shall bear the stamp of clarity. This subject has, during the last year or two, received particular attention in the United States, though it might be thought that no more authoritative words have been written regarding technical language than those used a century and a half ago by Thomas Jefferson in that place where he describes as " the most valuable of all talents " that of " never using two words where one will do." Different topics require, of course, different literary treatment. There is, for example, no place for rhetoric on a gas account. Purely factual, it must just state the number of therms and their cost, plus meter rent. To embellish such a document with words, no matter how felicitous, might suggest to the recipient that the charge per therm was swollen by the cost of the services of some highbrow in the gas office. A tender is in quite another category ; its composition and the clarity with which it is set forth are factors not without significant influence upon those whose business it is to examine and report on it. Evidence of carelessness in the preparation of tenders, particularly that kind of carelessness which results in incomprehensibility, has nullified many a proposal and will continue to nullify others. It often happens that the men whose business it is to analyse and report on tenders have had, at some stage in their training, experience in preparing them. Such men know what to look for and nothing is more likely to render them critical than evidence of slovenliness on the one hand or slickness on the other. A tender is a very important document and ought always to be regarded not only as the main literature of salesmanship, but as the written representative of the entire organisation from which it emanates. To be effective a tender must satisfy the persons to whom it is addressed that it contains no ambiguity. It must also convince them that it has been prepared by people pledged to perform what they have promised. The good contractor will always regard it as an obligation that he shall give the customer what he thought he bought, and happy is the contractor who succeeds in conveying to the potential customer that it is his intention so to do.

We get a good hint of what is truly effective either in an advertisement or a tender, in the commendation by Coleridge of the writer (he has Daniel Defoe in mind) " Who makes me sympathise with his presentations with the whole of my being." This was what Defoe excelled in accomplishing, and it is certainly the key to success in that expository work which lies at the very heart of advertisement. There is, however, no such thing as uniformity of mind among the vast company of those to whom the advertisement may be addressed. For example, the language of automobile advertisements ranges from the description in plain Anglo-Saxon of what is offered, to such syncopated calls as those which are currently addressed to the car-buying public in the United States. We quote : " Drive a ' ..... ' to-day for a glorious double thrill. There'll be pride in your heart, a torrent at your toe-tip. What more could anyone want ? Here's ' stop-and-go ' response as fast as thought itself. A hill helps, high or low, it's left behind without a sign of effort and passing definitely pins it down. Gun it ! and instant, flashing power sweeps you swiftly by the loitering car ahead. No drag, no lag—just safe and certain ' go ' ".

Neither Defoe nor Thomas Jefferson could or would have composed anything like this and we wonder what Horace might have thought about it ! Ever enjoining brevity, he warned people not to encumber their thoughts by any words which " weigh down tired ears." Certainly in the publicising of technical developments—whether they be massive or minute—clarity, both textual and pictorial, must always remain the essential requirement. This becomes the more irreversibly true in what Dr. D. W. R. Morgan, speaking on the occasion of the seventy-fifth anniversary of the American Society of Mechanical Engineers, called " An era of technological complexity, advancement and radical changes." Already the vocabulary of power production has become greatly expanded by the arrival of atomic energy and while the application of this energy may for the present be limited to the generation of heat, we stand at the opening of a new era when vast developments lie just beyond the horizon. That these developments must place new demands on technical publicity will be manifest to anyone acquainted with the scope, complexity and cost of tenders for atomic power plant. There was a time when, at the very birth of the industrial age, James Watt and Matthew Boulton discussed the matter of publicising the steam engine and we read how Boulton was moved to impress upon Watt that " no language will be sufficiently persuasive on that head except the good performance of the engines themselves." He therefore urged the speedy completion of the first Watt engine ordered for customers in London. To-day, the need is for the widest diffusion of accurate scientific knowledge, particularly that kind of knowledge which is derived not from studies only but from experience. We shall be wise to keep in mind the words of the seventeenth century philosopher in that place where he tells us how " Crafty men contemn studies ; simple men admire them ; and wise men use them ; for they teach not their own use ; but what is a wisdom without them and above them, won by observation."

## The Engineer
### 100 Years Ago
(OCTOBER 16, 1857)

" GOULDING'S AMALGAMATING MACHINE "

" A short time since we were invited to witness an experiment with the above-named apparatus, at Messrs. Redpath's works at Limehouse, but were unfortunately obliged to leave before it could be concluded, owing to the time necessarily consumed in separating the gold from the quicksilver, with which it was mixed. The apparatus consists of a long cylinder six or eight feet in length, and about twenty-four inches in diameter, having a spindle passing through its centre, upon which a number of blades are fixed. This spindle or shaft is turned by hand or otherwise, and keeps the water agitated with which the sand or crushed quartz containing the gold to be separated is mixed. At one end of the cylinder there is a small pocket, which forms a syphon having a rotating screw in it worked from the one above-named.

" This pocket, as well as the lower part of the cylinder, is filled with mercury (on the occasion named with about 100 lb weight), and the sand or crushed quartz mixed with water, which passes into the above pocket from a cistern placed above the machine, flows through the cylinder, being all the time agitated, and passes out at the opposite end. Most of the gold is taken up by the mercury in the pocket or syphon, but any which is not so caught is arrested by the mercury at the bottom of the cylinder itself, the water with the sand or quartz passing out freed from the gold. On the occasion referred to, a quarter of an ounce of gold dust was well mixed with about a cubic foot of sand, which with a considerable quantity of water was passed through the machine. The mercury was then drawn off and retorted in the usual manner, and the result was that nearly the entire weight of gold dust was recovered."

# A Seven Day Journal

### Accident at Windscale

AN accident occurred on Thursday, October 10, at the Windscale plutonium plant of the U.K. Atomic Energy Authority. It was found that certain of the uranium fuel elements at the middle of No. 1 reactor had become red-hot. The discovery was made during a routine shut-down period devoted to maintenance and the discharge of burnt fuel. Some of the overheated uranium oxidised, but most of the products are reported to have been trapped in the chimney filters. Combustion was brought under control by the injection of water. No. 2 reactor was shut down to release staff for the emergency, but we understand that there was no other reason. The reactors are air-cooled, unlike those in the nuclear power stations now being built. The latter are based on the Calder Hall model, and are cooled by carbon dioxide gas. Such mishaps as that which has just occurred at Windscale could not, therefore, come to pass.

Tests carried out in the locality since the accident have shown no alarming increase in radioactivity. Milk sampled last week end, however, revealed a radio-iodine level six times in excess of the permissible, and farmers were instructed to withhold their milk for the time being.

An inquiry is to be held, and it is hoped to have the findings next week. In the meantime, no detailed information is being released.

### Conference on Technology of Engineering Manufacture

THE Institution of Mechanical Engineers has just issued a provisional programme of arrangements which have been made for a conference on the technology of engineering manufacture, which is to be held on March 25, 26 and 27 next year. This conference is primarily intended to deal with what may be broadly termed metal forming and machining techniques, and to provide information of practical value on the latest developments in processes and techniques. It has been arranged in collaboration with the applied mechanics group and the industrial administration and engineering production group of the Institution, with Dr. D. F. Galloway as chairman of the planning panel. This planning panel has drawn up a balanced programme of papers and the conference will be concerned with three main divisions of manufacture—forming of materials, machining of materials, and inspection. It is stated that, in general, the papers will include a description of the progress made in a particular field, a discussion of the problems involved in the application of new or improved techniques, and an indication of the economies that have been achieved in practice.

The conference will be held in London and its venue is to be announced later. Two technical sessions will be held each day, and the papers for each session, which will be available before the conference, will be presented in abstract form for discussion. This procedure has been adopted because of the large number of papers to be presented in the limited time available; if there is sufficient time after each discussion authors will be given the opportunity to make brief replies to matters raised during the discussion. A complete list of the papers to be presented is not yet available, but will be published in due course in a booklet. We understand that about 1000 delegates will attend the conference. Bound volumes of the proceedings, including the papers, discussions and authors' replies will eventually be available from the Institution.

### Corrosion Convention and Exhibition

AT the Corrosion Convention dinner which was held in London on Tuesday, Mr. Harmar Nicholls, Parliamentary Secretary to the Ministry of Works, referring to the national significance of corrosion, spoke of the waste of our resources which had been allowed to occur in the past and which was still continuing in many directions. In many cases, only last minute chance discoveries had saved us from the evil consequences of our neglect; corrosion was a case in point. The replacement of corroded domestic hot water tanks alone cost the country £20,000,000 annually, and that of underground pipes an equal amount. Total annual corrosion losses in Great Britain had been estimated at £600 million, and those for the whole world probably amounted to several thousand million pounds, much of which was preventable. Proposing the toast "The Fight Against Corrosion," Sir Hugh Beaver, president of the Federation of British Industries, warned the audience against letting words become an alibi. He said that although everybody was cursing corrosion, this attitude appeared to be singularly ineffective, like the Bishop of Reims' curse upon the thieving jackdaw, when "no one seemed one penny the worse." It was essential to get action, and in order to do so, he would advise the assembly to concentrate on limited objectives, in the form of perhaps half-a-dozen concrete proposals.

At the Corrosion Convention, organised by the Leonard Hill Technical Group, which took place at the Central Hall, Westminster, on October 15 and 16, thirteen papers on corrosion and allied topics were presented. In conjunction with the Convention, a Corrosion Exhibition by nearly sixty firms and organisations was held at the Royal Horticultural Society's Old Hall, Westminster, from October 15 to 17.

### Professional Engineers

THE decline in the number of professional engineers in this country was the theme of an address delivered in Glasgow last Monday by Sir William Stanier, F.R.S., president of the Engineers' Guild. Sir William said that Britain had fallen behind other countries in the matter, and that urgent steps were necessary to remedy the situation if prosperity was to be achieved. It was doubtful, he added, whether the expansion rate for the training of 100 per cent more professional engineers by 1970 was likely to be achieved. Unless young people knew what engineering had to offer them, and unless they saw in the profession equal opportunities for advancement with other careers, there was a risk that some of the best would turn elsewhere.

Sir William went on to say that the Engineers' Guild had a programme designed to meet these problems, but it needed the support of the whole of the engineering profession. This programme included the establishment of a definition of the engineering profession, encouragement for the engineer to equip himself for management positions, a survey of salaries and conditions, and a comprehensive public relations scheme. There still existed, Sir William remarked, widespread ignorance of the responsibilities which the professional engineer carried for the future wellbeing of humanity. If that continued, it was likely to affect not only the status of the country, but also future recruitment to the profession.

### Seven Million Motor Vehicles

THE British Road Federation has just published the 1957 edition of its booklet, *Basic Road Statistics*, thus bringing up to date the collection of statistics about Britain's road system and motor vehicles which it contains. Attention is drawn to the continuing increases in the number of motor vehicles on the roads and it is pointed out that there are now (October, 1957) 7,250,000 of them.

The Federation is at pains to explain that since 1954, not a mile has been added to the trunk road system, although vehicles have increased in number by about 1,500,000. The total road expenditure in 1955/56 was £110 million, which included £13,000,000 for new roads. The total casualties on the roads in 1956 were 267,960, including 5367 killed. An estimate of the cost to the community of road accidents in 1956 is put at £169 million, that is about 50 per cent greater than the total expenditure on the roads.

### Advice to Young Scientists

ADDRESSING the sixth form at Hampton Grammar School last week, Sir John Cockcroft took as his title "The Implications of Science and Technology in the World of the Future." He opened by suggesting that the present age might in the future be thought of as one of the Golden Ages of Science, comparable with the best period of classical civilisation or with the Renaissance. Sir John then reviewed the work of the last sixty years or so in the fields of physics, chemistry and biology, sketching in lightly the details of this huge canvas.

"We are necessarily a trading nation," said Sir John, "if we are to double our standard of living in the next twenty years we will have to import still more raw materials and food and must export goods . . . in return." These commitments could only be met by continually developing new kinds of product. The essential raw material was the brains and enthusiasm of the younger generation. We needed to double our working population of scientists and engineers in fifteen years, and Sir John hoped that those of his hearers who were interested in science would help to promote the future of Britain. Science, however, was not the whole of life. Large organisations worked well or badly depending on the human qualities of their leaders, so, said Sir John, "when you are urged to continue with some humanistic studies in the sixth form, or to continue with French or German, don't think it a waste of time." "More important still," he emphasised, "is the enjoyment which the Arts can bring you throughout the whole of your life." The development of science had brought great dangers as well as great promise, and these required the continual attention of the best brains of our time. A democratic society required also the sustained interest of all who had intelligence enough to know their importance. After urging the boys to take interest in international affairs, and to get to understand the views of men and women in other countries—we were very much in need of increased understanding between nations—Sir John concluded by saying that he was an optimist for the future of our country and the human race. It was for the new generation to grasp the opportunities.

# Theory of Shaft Whirling

## A FUNDAMENTAL APPROACH TO SHAFT WHIRLING

By E. DOWNHAM, B.Sc. (Eng.), Ph.D., A.F.R.Ae.S.*

No. II—(*Continued from page 522, October 11*)

*The introduction in modern aircraft of complex engine-propeller installations, and of axial-flow compressor turbines with high rotational speeds and intricate construction, has brought the old problem of shaft whirling once again into prominence. Not only has it become necessary to estimate critical speeds of individual power plants with accuracy, but regard has to be paid to the flexibility of the mounting structure and the effect that even momentary and incipient whirls may have on an aircraft structure. In this article an attempt has been made to show the pitfalls made by early writers on the subject, and to establish clearly the basic theory on the lines indicated by Jeffcott. An experimental approach is then described, and results presented, which, combined with the theoretical approach, provide a firm foundation for a study of the more complex whirling problems.*

### DESCRIPTION OF THE MODEL SYSTEM AND EXPERIMENTAL TECHNIQUES

*Basic Requirements.*—The design of a model rig for experimental investigations of the theory of shaft whirling is not difficult providing certain fundamental requirements are met. In fact, simplicity in design is most desirable. It is important that the initial conditions of shaft support and balance should present the least number of unknown parameters. The effect of bearings on the effective stiffness of a system can be very large and differ appreciably when the shaft is stationary or rotating. For investigations at rotational speeds near the critical the balance of the system is important and the system should be, initially, as close to exact balance as possible so that the whirl amplitude at the critical speed can be controlled by creating controlled unbalance of the rotor.

The size of rig is not important for experiments of this kind. In fact, the smaller and more flexible the rig, the easier it is to obtain accurate results. For a simple rotor system the maximum whirl amplitude will usually occur at the rotor and this will be the best place to measure the whirl. In the case of a two-bearing shaft with rotor between bearings the movement of the rotor can only be measured by means of instruments near to or touching it, whereas for a cantilever shaft the maximum amplitude occurs at the free end, which means that direct photographic methods can be used for recording the motion. It is with the above precepts in mind that the rig described below was designed.

*The Model Shaft-Rotor System.*—Photographs of the model rig are shown in Fig. 4. The rig was designed around a silver steel shaft, 13in long and ¼in diameter ; this is a stock size and by a process of selection from a number of rods it was possible to obtain shafts which were practically straight when tested on a surface plate. For the reasons stated earlier, a cantilever system was chosen. The silver steel rod was fixed in the end of a 1in diameter driving shaft by means of a split collet. The driving shaft was carried by two taper roller bearings set 6in apart in the main bearing block. By reducing the clearance in the taper roller bearings to a minimum it was possible to provide almost 100 per cent encastré end conditions for the cantilever shaft. The effective length of the test shaft was 12in and provision was made to support the shaft near the free end by means of a flexible outrigger bearing. The outrigger bearing consists of a ¼in I.D. self-aligning bearing supported by four springs disposed at 90 deg. about the axis of the shaft. The springs could be arranged to provide either equal or unequal stiffnesses in the two principal planes.

A Schrage motor was used to drive the test rig through a 10 : 1 ratio step-up gearbox giving a speed range of 0–20,000 r.p.m., if required. A fine-speed control was obtained by means of a friction brake fitted to the main driving shaft between the taper roller bearings. By setting the motor speed to give a shaft speed just above the critical speed of the system and then controlling the speed by means of the brake, the whirl amplitudes and patterns at shaft speeds close to the critical (where amplitude is very sensitive to shaft speed) were easily explored. The accuracy of this method is confirmed by the small degree of scatter of the experimental points plotted near the critical speed.

For the preliminary investigations, designed to check the efficiency of the rig and operating techniques, a rotor of negligible inertia, i.e. concentrated mass, was used. This rotor was 2in diameter and consisted of two eccentric rings one inside the other, so adjusted that by rotating one ring relative to the other the c.g. of the rotor could be offset from the centre of the shaft by as much as 0·2in. The actual position of the c.g. was readily established by means of a graduated scale engraved on the outer ring, corresponding to a datum line on the inner ring.

*Experimental Techniques.*—The whirl paths at the free end of the shaft were recorded by means of a modified aerial camera fitted with an extension tube to carry the lens, giving an optical enlargement of 5·6 times. The whirl amplitudes were kept within approximately ±¼in by means of a leather guard ring behind the flexible outrigger bearing. Recorded amplitudes on the film were therefore of the order of 1½in maximum. For moderate amounts of rotor unbalance the slopes of the resonance curves above and below the critical speed are almost equal at ¼in amplitude. It is therefore considered reasonable to assume that the critical speed lies midway between the values given by the two curves at this amplitude.

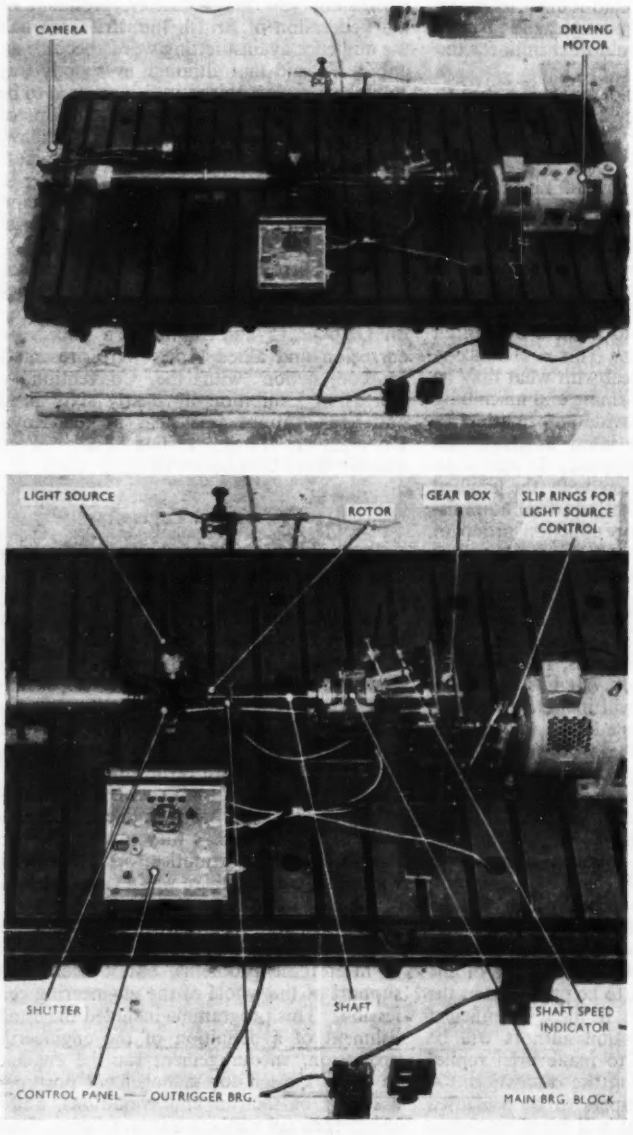


Fig. 4—Model whirling rig

The recording technique found to be most suitable for the optical system described above is one whereby the rig is normally operated in subdued lighting and a small highly polished "pip" on the centre of the shaft at the free end is intensely illuminated for a controlled period of time with an open shutter on the camera. For this purpose the normal "roller blind" shutter in the camera was replaced by a solenoid-operated shutter of the "Venetian blind" type in front of the lens. The light source was controlled by means of a simple electronic timer, which permitted illumination over a period of from one-tenth to five seconds as required.

When plotting amplitude frequency curves, it is essential to know

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the exact speed of the shaft when the whirl amplitude is recorded. Direct-reading tachometers were found to give inaccurate results and therefore the shaft speed was measured electronically by means of an inductance proximity pick-up placed behind the main bearing block near a clip rotating with the shaft. The pick-up formed part of a carrier-operated, frequency-modulated, tuned circuit, the output of which was amplified and used to operate a C.R.O. The C.R.O. was photographed by means of a continuous 35mm film camera with shutter removed. Records of shaft speed and whirl amplitudes were synchronised by switching at the control panel, the shaft speed being obtained by comparison with a mains-operated 50 c/s timing signal.

In order to record the deflection form of the vibrating (or whirling) shaft, the shaft was plated and polished and illuminated along its upper edge. A half plate camera was used for photographing the shaft, a shutter speed being chosen to give open shutter for a little more than one vibratory cycle of the shaft. The deflection form was then obtained with added accuracy by projecting the plate on to a flat screen with 4× enlargement and measuring the deflections at increments down the length of the shaft.

The natural vibrations of the rotating system were excited at non-critical speeds by means of a motor-driven crank elastically coupled to the shaft. Although the excitation of the shaft was linear, it was found to be effective in exciting the circular vibrations due to the inertia coupling. The vibratory motion of the shaft was measured by means of an inductance proximity pick-up of the same type as that used to record shaft speeds. The frequencies of the natural vibrations of the rotating shafts were obtained at various speeds of shaft rotation by running the shaft at a particular speed and exciting it laterally over the required frequency range. Resonances were observed visually on a C.R.O. and then recorded to give accurate frequency measurements. The range of shaft speeds over which investigations were carried out was chosen to cover speeds from zero r.p.m. to a value well above the critical whirling speed of the shaft.

## Experimental Results

A number of preliminary experiments were carried out to establish the operating characteristics of the test rig, and the whirling characteristics of systems similar to those treated theoretically in the foregoing were investigated. In the correlation between theory and experiment the effects of damping have been ignored, the prime effect being on the whirl amplitude, and only of second order on the critical whirling speed.

*The Simple Cantilever Shaft (Unsupported)*—In Fig. 5, the effect of rotor eccentricity *a* on whirl amplitude at various rotor speeds is plotted. By plotting whirl amplitude/rotor eccentricity as the ordinate, theory predicts that all points should lie on a single amplitude-frequency curve. The rotor eccentricity was varied from 0·06in to 0·16in in equal increments of 0·02in. To obtain the absolute value of the eccentricity it is necessary to take account of the effective mass of the shaft at the rotor. For the system considered, the weight of the rotor is 0·095 lb and the equivalent weight of the shaft was calculated to be 0·04 lb, giving a total tip mass of 0·135 lb weight. The c.g. of the equivalent rotating mass is obtained by reducing the rotor eccentricity by a factor 0·095/0·135 = 0·7 approximately. Measured deflection forms of the non-rotating shaft vibrating laterally and of the whirling shaft were compared with the calculated static deflection form and agreed to within 2 per cent, thus confirming the accuracy of the experimental technique adopted.

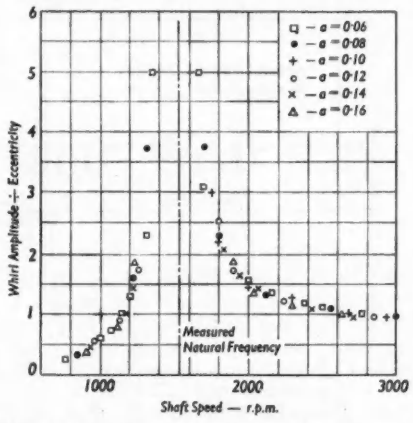



**Fig. 5—The effect of rotor eccentricity (*a*) on the whirling shaft-rotor system**

In order to assess the effect of assembly tolerances on the operating characteristics of the rig, experiments were carried out with minimum clearance and with 0·010in clearance in the main taper roller bearings. At the same time, the measured critical whirling speed was compared with the measured natural frequency of the non-rotating system and the natural frequency obtained from a theoretical calculation based on measured stiffness of the system. The results of these experiments are contained in Table I. For both cases of bearing clearance the three frequencies are in good agreement, but the increase in main bearing clearance is seen to reduce the three frequencies equally by as much as 4 per cent. This would indicate that the main bearing clearance affects the critical conditions of shaft stiffness, but does not otherwise affect the whirling characteristics of the system.

Whilst the above experiments were being carried out, an interesting phenomenon was observed and recorded. It was found that when the shaft was rotating at speeds above the critical speed, a slight disturbance gave rise to an unstable vibration of the shaft. The magnitude of the vibration increased exponentially until the guard ring was struck. The initial instability was also noted to be a function of the magnitude of the disturbing force, being only obtained after fairly heavy

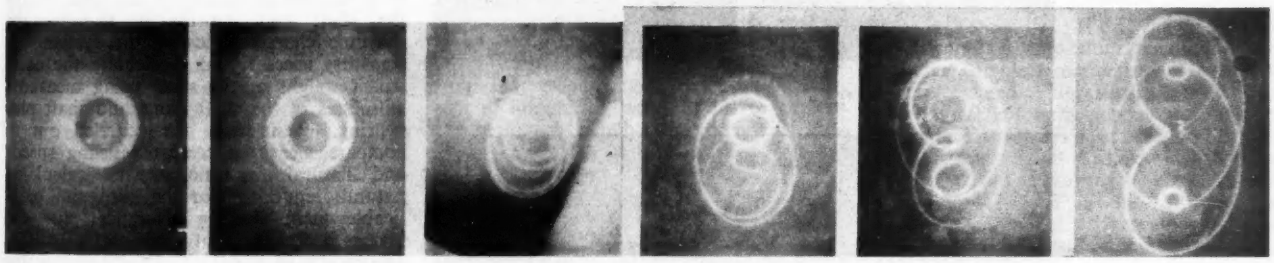



**Fig. 6 (upper)—Transient whirl producing instability of a cantilever shaft carrying an unbalanced rotor, and rotating at a speed above its critical speed**

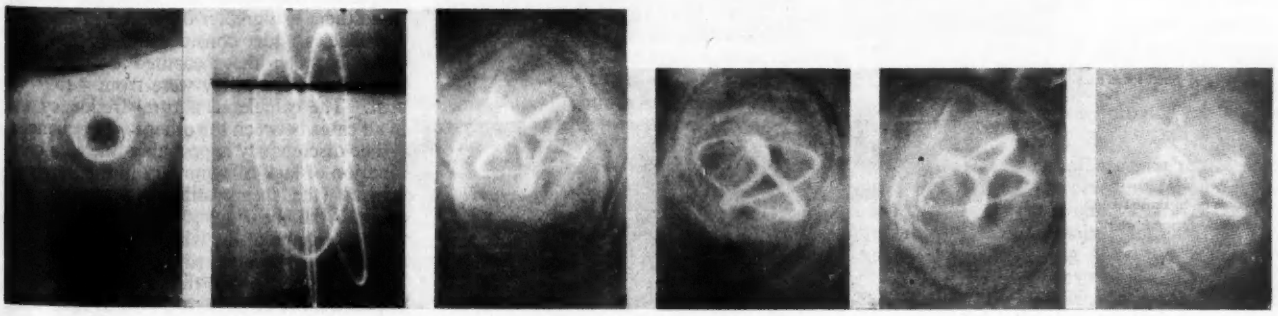



**Fig. 6 (lower)—The decay of a transient whirl of a cantilever shaft carrying an unbalanced rotor, and rotating at a speed below its critical speed**

blows on the shaft, except at speeds of about twice the critical speed, when the system was inherently unstable.

For shaft speeds below the critical speed, the system was quite stable, although if subjected to a large disturbing force the subsequent transient whirl decayed rapidly until an amplitude was reached slightly larger than the undisturbed whirl amplitude, after which the rate of decay was appreciably reduced resulting in a transient whirl of low decrement. Under these conditions the shaft was examined under stroboscopic light and it seemed that the motion consisted of a circular whirl at shaft speed (probably the normal unbalance whirl) and an elliptic whirl at the natural frequency of the system (which could be obtained when the shaft was not rotating by plucking the shaft). Records of the type of whirl obtained are shown in Fig. 6.

This phenomenon is caused by friction forces arising from working of the shaft in the split collet and, to a lesser degree, by internal hysteresis forces in the shaft. These forces have been described in detail by Robertson and Kimball and are shown to act in the line of the normal viscous damping force either in or out of phase, depending as to whether the shaft rotates below or above its critical speed. The magnitude of the friction force depends largely on the nature of the fit between shaft and collet and on the amplitude of vibration. When the shaft is whirling normally there is no working between shaft and collet and hysteresis forces are also absent. However, if the shaft is disturbed it would vibrate at its natural frequency, producing friction and hysteresis forces of this same frequency. Below the critical speed the damping and friction forces are in phase and the motion is stable, but above the critical speed these forces are in antiphase and, consequently, if the initial disturbance is sufficient to make the friction and hysteresis forces larger than the viscous damping force, instability will ensue and the rate of increase of the transient will increase with its amplitude. A similar effect has been investigated by Dr. B. L. Newkirk, who demonstrates the effect of oil action in journal bearings on the whirling characteristics of a system. The forces arising from the oil in the bearings are shown to cause critical whirling at frequencies of about twice the critical frequency.

It is interesting to note that in the experiments of Kimball and Newkirk the transient whirls arising from friction forces, &c., may be obviated by the introduction of flexibility in one of the bearings. This would account for the fact that when the cantilever shaft was supported by a flexible outrigger bearing, there was no sign of the friction whirl either above or below the critical speed.

TABLE I—*Comparison Between Natural Frequencies and Critical Whirling Speeds*

| Suspension details | Critical speed, R.P.S. | Natural frequency measured, c/s. | Natural frequency calculated, c/s. | Maximum error, per cent |
|---|---|---|---|---|
| Unsupported cantilever minimum brg. clearance | 26·4 | 26·6 | 26·5 | 0·75 |
| Unsupported cantilever +0·010in brg. clearance (axial) | 25·5 | 25·6 | 25·8 | 1·2 |
| Symmetrically supported cantilever, minimum brg. clearance | 42·0 | 43·75 | 43·6 | 4·2 |
| Symmetrically supported cantilever, +0·005in brg. clearance | 41·8 | 44·2 | 42·4 | 5·4 |
| Symmetrically supported cantilever, +0·010in brg. clearance | 41·6 | 44·4 | 42·6 | 6·8 |
| Asymmetrically supported cantilever, minimum brg. clearance | 34·6<br>40·6 | 37·4<br>41·6 | 36·6<br>44·0 | 8·1<br>8·3 |

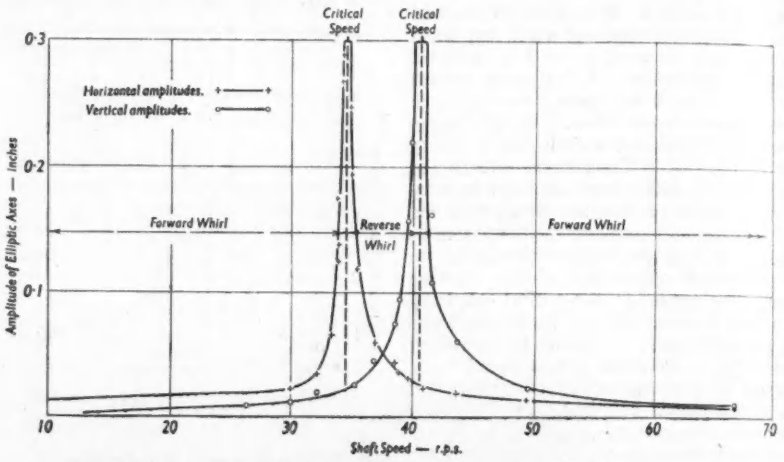



**Fig. 7—The cantilever shaft supported by a bearing of unsymmetric stiffness**

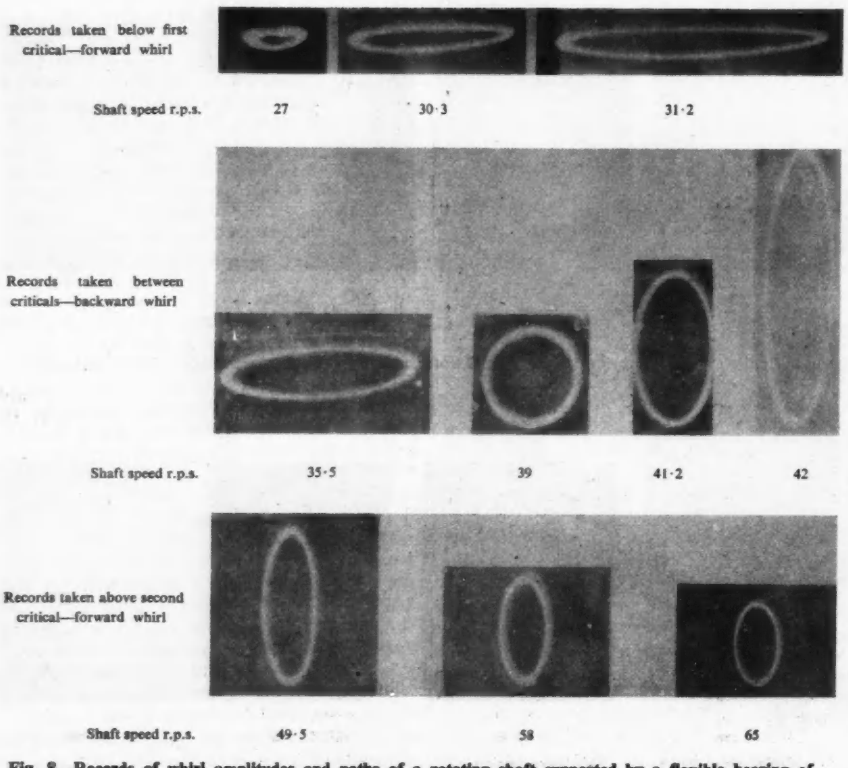



**Fig. 8—Records of whirl amplitudes and paths of a rotating shaft supported by a flexible bearing of unsymmetric stiffness**

As all the subsequent experiments have been made with the flexible outrigger bearing fitted, further investigations of this transient effect were not considered relevant to the intended programme of research.

*The Cantilever Shaft Supported by a Flexible Outrigger Bearing of Symmetrical Stiffness.*—The outrigger bearing was situated at a distance of 10in from the fixed end of the shaft and appreciably changes the dynamic characteristics of the system. It was first necessary to recalculate the equivalent weight of the shaft using measured stiffnesses of the shaft alone and shaft plus bearing. Tests were then carried out to compare measured critical whirling speeds and natural frequencies with calculated natural frequencies for the minimum practicable main bearing clearances and for increased clearances of 0·005in and 0·010in. The results of these experiments are shown in Table I above.

It is seen from these results that the increased main bearing clearance has little effect on the critical speed and natural frequency, but with the outrigger bearing fitted there is a greater difference in the three frequencies under consideration; the differences between the measured critical speed and natural frequency were from 4 to 7 per cent. The calculated natural frequency was in all cases between the other two frequencies.

The discrepancy is probably due to a combination of lack of symmetry in the outrigger bearing (the spring stiffness varied slightly around the bearing); this was apparent from the shape of the whirl path, which, near the critical, became slightly elliptical, and it was thought that the outrigger bearing imposed more constraint on the system when vibrating transversely without rotation than when whirling.

*The Cantilever Shaft Supported by a Flexible Outrigger Bearing of Asymmetric*

*Stiffness.*—The flexible outrigger bearing was fitted with springs which were stiffer in the vertical plane than in the horizontal plane and records taken over a range of shaft speeds. The results are shown plotted in Fig. 7. Typical records covering the speed range, showing the two critical speeds and the reverse whirl between the criticals (examined by stroboscopic light) are shown in Fig. 8. Again, a discrepancy between the critical whirling speeds and the natural frequencies was obtained which, due to the enforced asymmetry of the outrigger bearing, indicates that most of the effect is due to the functioning of the outrigger bearing under the different conditions.

### Conclusions

The initial experiments have shown that the use of a small model rig in conjunction with the techniques developed is suitable for studying the fundamentals of shaft whirling. At the same time, it has been shown that the Jeffcott theory applied to a simple system is basically correct in all details.

Table I summarises the experimental results from which it is seen that the greatest discrepancy in the comparison of critical speeds and natural frequencies is of the order of 8 per cent. Allowance must be made for this in further experiments, although it is not considered to be of great importance as the majority of the work subsequently carried out, deals with the rotating system and the comparison between the natural frequency of the stationary system and the critical whirling speed is of secondary importance. The transient whirl due to friction effects has been described to show the scope of the experimental technique.

*(To be continued)*

# Lubrication and Wear

*(Contributed)*

THE practice of international scientific bodies of holding frequent conferences often leads to a proliferation of second-rate reading material which is either a repetition of information which has already been disclosed or consists of elaborations of the trivial. But this criticism cannot be directed at the Conference on Lubrication and Wear, which was held at the Institution of Mechanical Engineers from October 1 to 3, because it is some twenty years since a similar meeting was held, which was at that time referred to as a "General Discussion." The fact that twenty years had elapsed provided a two-fold benefit. The material presented at the conference was relatively fresh, and an estimate of the advances which have taken place in this subject may be made by comparing this material with that presented in the earlier discussions.

By and large the first contrast between the two conferences was that, whereas descriptive treatments of engineering practice were quite prominent at the first conference, they were virtually absent from the proceedings of the second conference. This may reflect a positive advance. For the sake of illustration reference may be made to the recent presidential address of the Institution of Locomotive Engineers. Mr. E. S. Cox reminded his audience that in 1908 hot boxes were among the greatest handicaps of the day, but at the 1937 conference Sir Nigel Gresley stated that with over 10,000 carriage bearings on the railway with which he was connected, the return of "hot boxes" was often nil for a month and in other months would be only one or two. It can be inferred that by the time the last conference was held engineers had learned to design bearings which would carry their loads with complete reliability in all the quite highly developed engineering applications of the day, including high-speed railway practice, aircraft, and steam turbines. In the interim period two objectives have presented themselves—the provision of bearings for engineering developments which were unheard of in 1937, notably the gas turbine, and development of greater efficiency or economy. A change in the attitude of mechanical engineers is indicated by the title of the conference, which, on this occasion, embodied the term "wear." The inference is that the organising committee held the opinion that the science of lubrication was indeed well established, but that "wear" as a body of knowledge was only coming into being at this present juncture. Returning again to Mr. Cox's presidential address, "few if any bogie designs give a bad ride when new. If they do it is usually due to some obvious and easily remedied defect . . . Several years afterwards all is silence and the new design has joined the over-populated limbo of indifferent performers. To prevent or mitigate the effect of wear is therefore paramount, although less easy than appears at first sight. New materials, elimination of metallic contact, reduction in initial clearance are achieving this in all countries and here and there there are prototype bogies running which are maintaining good riding well into the 10,000 miles." It will be seen that, taking the homely example of the carriage bogie as representing what must occur in many phases of engineering, the problem has changed from that of making bearings effective to that of minimising wear so that machinery can be kept in a fully efficient running condition throughout the whole of its working life.

The possibilities of pretreating surfaces so that they will operate under substantial loads at considerable speeds without any lubricant and the possibility of very high-speed shafts being carried on self-generated air films are indicative of progress and the papers at the conference leave no doubt that research is proceeding rapidly into all aspects of lubrication and wear. The prizes to be gained are more compact cheaper construction, easier maintenance and economy in power. As mentioned in our October 4 issue, narrow bearings, by shortening of machinery arrangements, may produce economic advantages far out of proportion to the mere saving in bearing material. Again, careful selection of lubricants in road passenger vehicles can lead to considerable savings in fuel.

The fact that most of the papers came from universities, government research institutions or the research departments of the larger firms may indicate a changing pattern of engineering endeavour. Whereas in former days one tended to get papers by all-round engineers, Sir Nigel Gresley being a typical example, the kinds of problem represented by bearing development are now the specialist concern of the research man in industry. But this picture may be distorted because there are possibly many members of the Institution of Mechanical Engineers other than research workers who could have made a contribution to this conference, but who did not in fact do so. They may not have contributed because of a fear that "application" engineering would somehow receive less credit in the eyes of the Institution referees than theory or research. Alternatively, the growing tendency to concentrate the solution of technical problems into the research departments of firms may have led to a situation in which the operating and manufacturing sides are producing no new information. If the latter is the true situation there is a danger that research departments may become isolated from the hurly-burly of manufacture, sales and operation, so that they produce elegant investigations which deal with topics quite unrelated with the true industrial situation. Fortunately, in several instances, papers at the conference revealed that research departments had, in fact, carried out operational studies in service and had thereby obtained an insight into the nature of the real problem.

One in five of the papers at the conference emanated from the Mechanical Engineering Research Laboratory. At first sight this proportion appears excessive, but, when it is recalled that this laboratory was created to continue and expand the work of the Engineering Division of the National Physical Laboratory, which contributed largely to the 1937 conference, it is seen to be evidence of a continuing tradition.

There was much discussion at the conference concerning the laws of wear, but little agreement on the nature of the basic mechanism or mechanisms whereby material may be detached from a working surface. Knowledge is only won completely when it can be expressed in quantitative terms. It was particularly distressing, therefore, to note that, of all the workers who were carrying out wear investigations, each had his own method of testing, and it was virtually impossible to compare the data of one paper with that of another. It may not be possible to prescribe a satisfactory method of test until the complete mechanism of wear has been elucidated. Nevertheless, those who are responsible for the purchase and inspection of lubricating oils must have test methods and it is not without satisfaction that it can be claimed that the machine which was originally developed in the Institution of Automobile Engineers' laboratory for the study of lubrication of automobile gears has proved of value in assessing lubricants for heavily loaded marine gears for naval service and its use is at present embodied in Admiralty specifications as a test method.

Specification and testing of crankcase oils still presents a problem and it is regrettable that we cannot to-day reliably assess the merits of a heavy-duty oil without subjecting it to an engine test costing some £800. The more extensive use of the B.S.I. Mark Scheme might, however, provide an interim solution.

The great volume of research represented by the conference proceedings should be a source of great satisfaction to all concerned, but the problem remains, and it is a vital problem, of ensuring that the results of research at present available are embodied adequately into engineering practice and, moreover, that further research is, in fact, directed towards solving real problems in engineering and is not dissipated in elaboration of idealised conceptions.

# Recent Developments in British Naval Main Propulsion Steam Turbines*

By the late F. J. COWLIN, O.B.E., M.I.Mech.E., and A. F. VEITCH

No. I

*This paper shows the considerable advances made in British Naval main propulsion steam turbines since the end of the 1939/45 war. These advances include improvements in design and manufacture which have enabled higher steam conditions to be utilised, the overall result being improved performance which, together with weight and space reduction, results in increased endurance. The initial impetus resulted from wartime experiences and led to the three designs of "Daring" turbines, one of which is discussed. The next step was an investigation into all the factors affecting performance, endurance, &c., and the various problems and resulting improvements are discussed in that section of the paper dealing with "Y.E. 47A." The "Y.E.A.D. 1" turbine design is a further development of the "Daring III" design following the "Y.E. 47A" investigations. The special requirements of the anti-submarine frigates required turbines which incorporate some rather unusual design features and they are described under the heading of "Y.100," together with shore and sea trials results.*

INVESTIGATIONS were instituted into the performance of British naval craft during the war in the Pacific by the Royal Navy, and a Propulsion Committee was set up.

The work of the Turbine Sub-Committee resulted in the submission of five designs for turbines of 27,000 s.h.p. to meet an outline specification laid down by the chairman on behalf of the Engineer-in-Chief's Department. Of these it was decided that the two submitted by the English Electric Company best met the Admiralty requirements.

The first of these designs, "S.T.N.1," was a two-cylinder reaction design preceded by a two-row Curtis wheel based broadly on a design of which the U.S. Navy had supplied details.

The second design, "S.T.N.2," was of impulse construction making use of alloy steel rotors and originally referred to as a "limit" design, the total weight being some 30 per cent lower than that of any other design submitted.

The Admiralty decided to develop both "S.T.N.1" and "S.T.N.2" for installation in the "Daring" class of destroyers after full shore tests.

The first section of the paper is devoted to the "Daring III" design—of advanced all-impulse type, designed and developed by the English Electric Company.

The "Daring" class twin-screw ships have main engines designed to meet the Admiralty requirements issued in 1944. Each set of turbines supplies 27,000 s.h.p. plus 10 per cent overload, with steam at 565 lb per square inch absolute and 825 deg. Fah. The steam pressure varies with the load, rising to 655 lb per square inch absolute at 10 per cent power. The steam temperature remains constant. The vacuum at full power is 27·5in Hg (Bar. 30·0in). An astern power of 9000 s.h.p. is specified when supplied with steam at 515 lb per square inch absolute, 825 deg. Fah.

The turbines were to be designed to attain a high efficiency at all powers with special emphasis on the range between 20 per cent and 40 per cent full power. During the life of the ship full power would not be required for more than 2000 hours. The Admiralty stressed that interchangeability was particularly important, both for individual items and complete assemblies, irrespective of several manufacturers being involved.

*General Arrangements.*—Preliminary investigations showed that the best turbine arrangement from the point of view of weight, space and performance, &c., was a two-cylinder cross-compound arrangement with the power split more or less equally between cylinders at full load to ease the design of the double reduction locked train gearcase.

*H.P. Cylinder.*—In 1944 current practice in the Royal Navy was to install impulse-reaction h.p. turbines and all-reaction l.p. turbines, although some Brown-Curtis all-impulse turbines were still in service. This latter type was very much out of favour because of the serious troubles constantly arising from blade vibration, wheel flap and wheel loosening. It was felt, however, by the English Electric Company that for the requirements as stated above, an all-impulse design would prove advantageous, as was adequately proved during shore trials.

*Steam Chest.*—It was decided to use a steam chest cast integrally with the h.p. cylinder. This removed the complicated steam piping resulting from separate nozzle boxes.

*Valve Gear.*—In the interest of economy over the required power range, nozzle control valves were provided for loads of 20 per cent, 40 per cent and 60 per cent, each valve supplying steam to its individual group of nozzles. Above 60 per cent power a by-pass valve admitted steam to a belt situated between stages 3 and 4 in the h.p. turbine. All valves opened sequentially. The astern valve was mounted on the l.p. cylinder.

*L.P. Cylinder.*—A double-flow l.p. cylinder incorporating a solid gashed type rotor, was decided upon. Blade heights were halved, thus reducing the overall diameter, enabling the design to be based upon higher rotational speeds without any increase in stress levels.

*Materials.*—A 3 per cent chrome-molybdenum steel was chosen for the solid forged rotors.

A.T.V. steel was eventually chosen for the blades with the exception of the last two l.p. rows of blading, which were made of a special manganese-nickel steel and chromium plated in line with the maker's established land practice.

All the fixed blading took the form of nozzles, and here, with the exception of the last two stages, a built-up construction was employed, consisting of A.T.V. steel nozzle segments fixed to mild steel centres. The last two l.p. diaphragms were made of cast steel with A.T.V. steel nozzle division plates cast in.

Due to the increasing demand for more space for armaments, there is greater need for lighter and more compact machinery and the following table throws light on the topic of weight and space.

TABLE I

| | "Daring III" | "Daring II" | "Daring I" |
|---|---|---|---|
| Two h.p. turbines, including valves, pipes, &c., tons | 21·2 | 45·3 | 38·0 |
| Two l.p. turbines, including valves, pipes, &c., tons | 37·8 | 44·1 | 44·1 |
| Total ... ... ... | 59·0 | 89·4 | 82·1 |
| H.p. rotor bearing centres | 4ft 9¼in | 5ft 10¼in | 6ft 7⅛in |
| L.P. rotor bearing centres | 7ft 10in | 8ft 6¼in | 8ft 6¼in |

*Summary of Shore Trials.*—Fig. 1 shows the steam consumption rate, including gear losses for "Daring III" turbines over the power range. There was but little difference between the specific steam consumptions for "Daring I," "Daring II" and "Daring III," as no design proved superior to any other over the whole power range. It can be seen how closely the specified requirements have been achieved, the curve being practically flat from 20 per cent to 100 per cent power, the lowest point being at about 40 per cent power.

*Conclusions.*—The "Daring III" turbines produced an economy combined with weight and space figures superior to any other main propulsion unit for naval purposes previously built in this country.

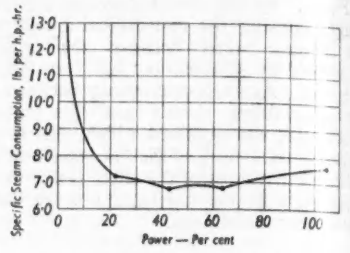



Fig. 1—Consumption rate, "Daring III"

Table II summarises the salient features of the "Battle" class, "Weapons" class and the "Daring III" propulsion machinery for purpose of comparison.

TABLE II

| | "Daring III" | "Weapon" Class | "Battle" Class |
|---|---|---|---|
| Full power s.h.p. per set | 27,000 | 20,000 | 25,000 |
| Steam conditions at full power, lb per sq. in | 550 | 350 | 350 |
| Deg. Fah. ... ... | 825 | 750 | 650 |
| Steam consumption at 20 per cent power, lb per s.h.p. hr. | 7·25 | 8·8 | 9·8 |
| Steam consumption at 100 per cent power, lb per s.h.p. hr | 7·52 | 7·7 | 8·4 |
| Specific weight of turbine, lb per s.h.p. | 2·45 | 4·74 | 4·83 |
| H.P. rotor, bearing centres | 4ft 9¼in | 9ft 11in | 9ft 4¼in |
| L.P. rotor, bearing centres | 7ft 10in | 11ft 8⅞in | 12ft 6¼in |

## "Y.E. 47A" Investigation

In 1947, following the advances made in the design of the machinery for the "Daring" class, the Admiralty invited the English Electric Company to co-operate with Yarrow and Co., Ltd., in order to investigate the further gains that could be achieved by elevation of steam conditions and to determine the characteristics of the machinery which should be developed to utilise these conditions. The various reports produced and recommendations made covered all aspects of the whole of the machinery suitable for a destroyer of "Daring" hull form.

The investigation assumed the title of "Y.E. 47A."

*Specific Requirements.*—The requirements were to establish the most advantageous arrangement, design and steam conditions for a set of main engines to develop a maximum power of 30,000 s.h.p., due emphasis being given to the following factors :—

Reliability ; minimum weight and space ; maximum economy between 20 per cent and 40 per cent of full power; ease of maintenance ; ease of production ; interchangeability ; operation by personnel with limited training.

*Performance.*—Due to the fact that turbines for naval purposes have to operate over a wide speed range, it is essential that the steam consumption at cruising powers does not unduly prejudice the consumption at full power as the steam rate of the latter determines the boiler capacity. On the other hand, if the turbines be designed to give a maximum efficiency at full power, the efficiency at cruising speeds is adversely affected, which seriously reduces the ship's endurance at those speeds.

*Steam Conditions.*—It is established that, within wide limits and for a fixed back pressure, the higher the initial steam pressure and temperature the lower will be the fuel rate of the cycle, provided that the efficiency of the various components of the cycle can be reasonably maintained.

In the case of a naval vessel, however, fuel rate is not the only criterion. The space occupied by

* The Institute of Marine Engineers. October 8. Abstract.

machinery and its overall weight are equally important. A useful standard adopted during this investigation was made by fixing a maximum permissible weight of machinery plus fuel, and comparing the ship's radius of action with the various designs of machinery described below.

Early in the investigation it became clear that a definite limit would be set to any increase of initial pressure and temperature by the increased weight of machinery necessary to withstand it. The predominant component was the boiler plant and main steam piping.

*Cruising Turbines.*—Most warships only require to develop full power for a very limited part of their lives, the remainder of the time being spent cruising at reduced speeds. It thus becomes a criterion of design that they require economy at two widely separate powers. First, full power, and, secondly, at some cruising power which may be as low as 5 per cent. The relation between these two powers is only fixed by the operational requirements for which the ship is to be designed.

Now the general law connecting power developed and steam rate, ignoring irregularities due to throttling, for any variable-speed turbine as used for marine propulsion is shown in curve *A* in Fig. 2, from which it will be appreciated

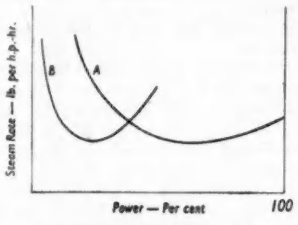



**Fig. 2—Power steam rate**

that the lowest steam rate s only obtained at one particular power dependent upon the requirement for which the turbine is designed. Performance falls off at higher or lower powers, particularly for the latter.

The only way in which the relative performance at low and high powers can be changed is by moving the point at which the minimum steam rate is obtained either to the right or the left when for practical purposes the curve will move bodily in the same direction.

Where, however, it is required to improve low power performance without prejudicing full power performance, it is possible to introduce a second or "cruising turbine" having a characteristic shown by curve *B*, which, being designed for the smaller steam flow at reduced power, will give a much improved performance at such powers than curve *A*, as shown. It is then possible to use turbine *B* for low powers and to change to turbine *A* for higher and full power.

*Boiler Characteristics.*—formerly normal naval boilers gave a steam temperature rising with increasing output. This was known as "normal characteristic" and was inconvenient as high temperatures were produced when rotational stresses were highest.

This problem can be eased by incorporating a form of superheat control designed to give the following :—Flat characteristic : constant temperature at all outputs ; inverse characteristic : fall in temperature with increasing output.

The "inverse temperature characteristic" has the desirable feature of producing the high temperatures in conjunction with low powers ; thus the maximum rotational stresses are only encountered with the reduced temperatures.

*Types of Main Engines Analysed.*—Nine different designs of main engines (as listed below) were analysed as accurately as possible without producing final and detailed designs. The estimated steam and heat consumptions are given in Figs. 3 and 4 respectively, but it must be emphasised that the results were of the first order of accuracy only. This did not, however, prevent the drawing of very definite conclusions regarding the relative merits of the various arrangements :

(*a*) "Daring" class with a "flat" temperature characteristic.

(*b*) "Daring" class with an "inverse" temperature characteristic.

*"Daring" Class*

| Power, per cent | Steam pressure, lb per sq. in, abs. | Vacuum, in Hg. | Steam temperature characteristic, deg. Fah. | |
|---|---|---|---|---|
| | | | Flat (curve *a*) | Inverse (curve *b*) |
| 100 | 565 | 27·5 | 825 | 825 |
| 61·125 | 625 | 28·53 | 825 | 1000 |
| 40·75 | 641 | 28·8 | 825 | 1050 |
| 20·375 | 651 | 28·95 | 825 | 1050 |

*Advanced Steam Conditions (Curves c to h inclusive)*

| Power, per cent | Steam pressure, lb per sq. in abs. | Vacuum, in Hg. | Steam temperature, deg. Fah. | | |
|---|---|---|---|---|---|
| | | | *c, f, g, h* | *d* | *e* |
| 100 | 1315 | 27·5 | 1025 | 1025 | 1025 |
| 60 | 1405 | 28·6 | 1025 | 1025 | 1050 |
| 40 | 1427 | 28·9 | 1009 | 1050 | 1100 |
| 20 | 1445 | 29·1 | 965 | 1050 | 1100 |
| 10 | 1450 | 29·1 | 950 | — | — |

(*c*) High-pressure, straight three-cylinder turbine for nominal boiler steam conditions of 1400 lb per square inch gauge, 1050 deg. Fah., with "normal" characteristic.

(*d*) High-pressure, straight three-cylinder turbine with nominally "flat" temperature characteristic at 1025/1050 deg. Fah.

(*e*) High-pressure, straight three-cylinder turbine with "inverse" temperature characteristic to 1100 deg. Fah.

(*f*) High-pressure, two-cylinder turbine, plus hydraulically coupled high-speed cruising turbine, "normal" temperature characteristic.

(*g*) High-pressure, two-cylinder turbine, plus hydraulically coupled low-speed cruising turbine, "normal" temperature characteristic.

(*h*) High-pressure, two-cylinder turbine, plus permanently coupled, overhung, high-speed cruising turbine.

*Comparison of Types Analysed.*—The variation in steam consumption with change of load for all the alternative schemes is shown in Fig. 3, and the heat consumption in Fig. 4, in which the steam conditions and vacua at the various loads are tabulated.

TABLE III

| Scheme | Load, per cent | | | | | | |
|---|---|---|---|---|---|---|---|
| | 10 | 20 | | 40 | | 60 | 100 |
| | | Cruising "in" | Cruising "out" | Cruising "in" | Cruising "out" | | |
| (*a*) Datum, B.Th.U. per s.h.p. hr. | 11,455 | — | 9,515 | — | 8,800 | 8,878 | 9,750 |
| (*b*) Improvement, per cent | Not calculated | — | 7·5 | — | 6·3 | 5·7 | Nil |
| (*c*) Improvement, per cent | 13·1 | — | 10·1 | — | 9·3 | 9·9 | 12·2 |
| (*d*) Improvement, per cent | Not calculated | — | 11·6 | — | 10·1 | 9·9 | 12·2 |
| (*e*) Improvement, per cent | Not calculated | — | 13·0 | — | 11·2 | 10·5 | 12·2 |
| (*f*) Improvement, per cent | 14·2 | 10·4 | — | 7·3 | 6·3 | 7·8 | 11·7 |
| (*g*) Improvement, per cent | 15·9 | 12·2 | — | 8·5 | 6·3 | 7·8 | 11·7 |
| (*h*) Improvement, per cent | 16·4 | 13·4 | 7·1 | — | 5·3 | 7·1 | 11·4 |

Table III has been prepared to show percentage differences in main engine heat consumptions of the various schemes. "Daring" class estimated consumptions with steam conditions as designed, i.e. flat temperature characteristic, have been used as the datum for comparison.

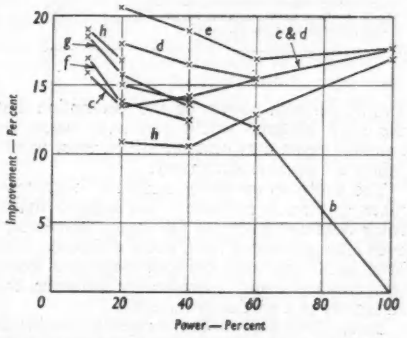



**Fig. 5—Percentage improvement in steam consumption, "Y.E. 47A"**

Fig. 5 shows the percentage improvement in steam consumption for all the alternative schemes at the various percentage powers. The improvements shown are only correct at the points for

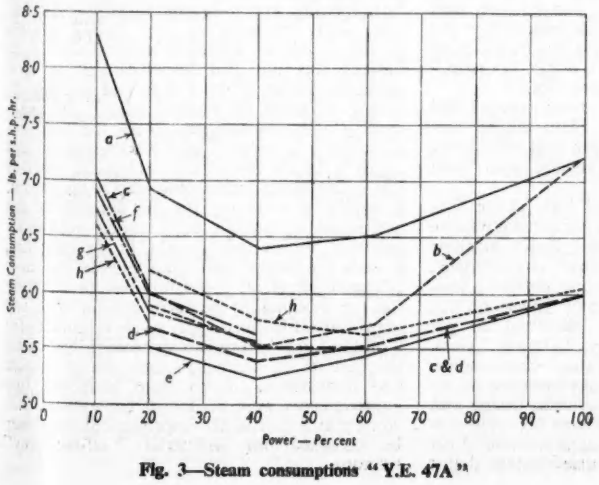



**Fig. 3—Steam consumptions "Y.E. 47A"**

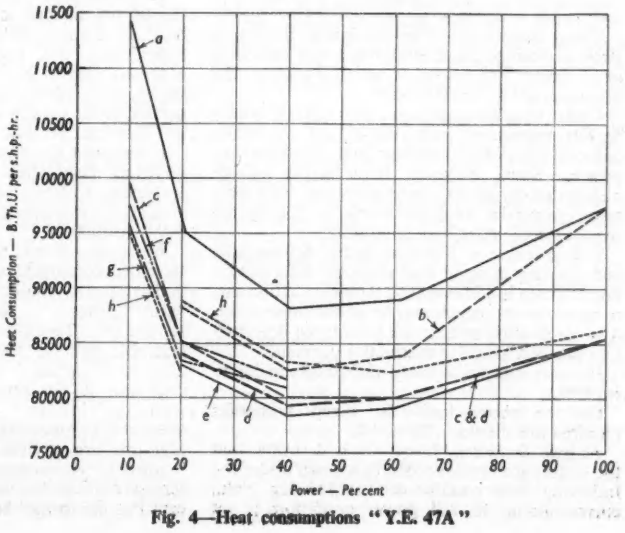



**Fig. 4—Heat consumptions "Y.E. 47A"**

which the calculations were made, viz., 10, 20, 40, 60 and 100 per cent. Improvements at intermediate powers between these points cannot be obtained from the curves.

All estimates of heat consumptions have assumed the condensate to be at the saturation temperature corresponding to the vacuum obtained.

### Material Requirements

The turbine arrangement under consideration was scheme (*e*), the straight three-cylinder machine with initial steam conditions of 1400 lb per square inch and 1050 deg. Fah. at maximum power, with "inverse" temperature characteristic. It was assumed that at 20 per cent power the maximum permissible steam inlet temperature would be limited by boiler difficulties to 1100 deg. Fah.

Under those conditions special properties would be required in the materials for the h.p. and i.p. rotors, but no difficulty would be experienced with the l.p. rotor for which the 3 per cent chrome-molybdenum steel as used in the "Daring" class would be suitable.

It was assumed that the maximum life requirements at full power need not exceed 500 hours but that at 20 per cent and 40 per cent power long life would be required.

*Stresses and Temperatures.*—Table IV gives the maximum stresses and temperatures to which the h.p. and i.p. rotors would be subjected at 100, 40 and 20 per cent powers on the assumption that the rotor material would eventually reach the ambient steam temperature, and stresses would follow the usual elastic theory.

The above temperatures can only be approximate, as there is evidence which suggests that a rotor does not reach the full steam temperature even after prolonged runs, and a difference of as little as 50 deg. Fah. between metal and steam temperatures could considerably influence the suitability of a particular material.

*Short Term Tests.*—The foregoing considerations indicate the following properties as being desirable for the rotor material :—

Table V

| | H.P. rotor | I.P. rotor |
|---|---|---|
| Ultimate tensile strength | Not less than 36 tons per sq. in at 984 deg. Fah. | Not less than 30 tons per sq. in at 865 deg. Fah. |
| 0·2 per cent proof stress | Not less than 27 tons per sq. in at 984 deg. Fah. | Not less than 23 tons per sq. in at 865 deg. Fah. |

*Creep Properties.*—The maximum rotational stress and temperature conditions upon the rotors occur under full power, at which, however, the life required is only 500 hours.

Under long life conditions (say 100,000 hours) both temperatures and stresses are materially reduced, the worst conditions being at 40 per cent power. Since, however, there is no reliable method of correlating short term and long term creep properties, it is preferable to specify the requirements under both conditions.

The criterion is the permissible deformation and, bearing in mind that the total deformation due to creep is additional to the deformation due to elastic stress, which may be of the same order, it is not considered that the total creep deformation can be allowed to exceed 0·1 per cent.

It is also essential to guard against failure due to rupture.

On the above basis the creep properties required are shown in Table VI.

*Fatigue Endurance Limit.*—It is desirable that the endurance limits should be known under the following three conditions : at 984 deg. Fah., corresponding to full power conditions ; at 877 deg. Fah., corresponding to 40 per cent power conditions ; at room temperature.

Table VI—*Full Power Conditions*

| | H.P. rotor | I.P. rotor |
|---|---|---|
| Total deformation in 500 hours : Not greater than 0·1 per cent ($2 \times 10^{-4}$in/in/hr) | At 984 deg. Fah. and 12 tons per sq. in | At 865 deg. Fah. and 10 tons per sq. in |
| Deformation at rupture : Not less than 5 per cent | At 984 deg. Fah. and 12 tons per sq. in | At 865 deg. Fah. and 10 tons per sq. in |

*40 per cent Power Conditions*

| | H.P. rotor | I.P. rotor |
|---|---|---|
| Total deformation in 100,000 hours : Not greater than 0·1 per cent | At 877 deg. Fah. and 5·6 tons per sq. in | At 660 deg. Fah. and 4·7 tons per sq. in |
| Deformation at rupture : To be stated... ... ... | At 877 deg. Fah. and 5·6 tons per sq. in | At 660 deg. Fah. and 4·7 tons per sq. in |

*Notch Sensitivity.*—Tests should be carried out to simulate as nearly as possible the effect of stress concentration due to unavoidable rapid changes in section and the effect of shock conditions at : 984 deg. Fah. ; 877 deg. Fah. ; room temperature.

*Damping Capacity.*—The inhibition of resonant vibratory stresses is best dealt with by selecting material having suitable damping capacity. It seems essential that damping properties should be known under the following conditions of operation representing long life : at 877 deg. Fah. ; at room temperature.

*Metallurgical Stability.*—It is essential that the material selected should have no undesirable metallurgical instability after prolonged heating in high temperature steam.

*Thermal Stress Cycles.*—It is essential that the material should be capable of withstanding the stress cycles induced by rapid variations in the temperature gradients without failure or material alterations to its physical properties.

Table IV

| | 100 per cent power, light draught | | 40 per cent power, deep draught | | 20 per cent power, deep draught | |
|---|---|---|---|---|---|---|
| | H.P. | I.P. | H.P. | I.P. | H.P. | I.P. |
| Nozzle box pressure, lb per sq. in ... ... ... | 1300 | — | 1410 | — | 1430 | — |
| Nozzle box temperature, deg. Fah. ... ... ... | 1025 | — | 1100 | — | 1100 | — |
| Wheel case steam temperature, deg. Fah. ... | 984 | 865 | 877 | 660 | 815 | 500 |
| Maximum bore stress, tons per sq. in ... ... | 18 | 15 | 8·5 | 7·1 | 5·5 | 4·6 |
| Average stress, tons per sq. in ... ... ... | 12 | 10 | 5·6 | 4·7 | 3·7 | 3·1 |

### General Conclusions

An analysis of the results of the "Y.E. 47A" investigation dealing with main engines, showed that the maximum temperature of the cycle had the most profound effect upon the cycle efficiency at all powers.

The effect of an "inverse" temperature characteristic on the heat consumption at part loads resulted in considerable gains over the cruising range, and this improved performance was obtained without having to use materials in the turbine any different from those required to meet similar boiler conditions, with either "normal" or "flat" temperature characteristics.

It was seen that increased steam pressure had relatively little effect upon main engine performance, approximately 4 per cent only being gained by increasing the pressure level from 600 lb to 1400 lb.

*Economy.*—There appeared little doubt that the most economical turbine arrangement was the high-pressure, straight, three-cylinder machine with "inverse" temperature characteristic, scheme (*e*). This alternative also showed a considerable gain at 100 per cent power on the existing "Daring" design. Between 20 per cent and 40 per cent power "Daring" class, with an "inverse" temperature characteristic scheme (*b*), approached the performance of the high-pressure, straight, three-cylinder design with "normal" characteristic, scheme (*c*). The difference between the two was approximately 3 per cent but the former had the disadvantage that it entailed additional boiler capacity owing to increase in the water rate at 100 per cent power.

Unless operational requirements were such that particularly low water rates were required at powers appreciably below 20 per cent, there did not appear to be any justification for considering the incorporation of cruising turbines.

*(To be continued)*

## Institution of British Agricultural Engineers

At a meeting of the Institution of British Agricultural Engineers, which was held in London on Tuesday last, Mr. J. M. Chambers delivered his presidential address. In the first part of the address, Mr. Chambers surveyed the development of power units for tractors and agricultural machinery, commenting briefly on the possibilities of the free piston gas turbine and the utilisation of nuclear power. He then went on to talk about "other stimulants to development in agricultural engineering," mentioning, in particular, pneumatic tyres, hydraulically-mounted implements and "self-propelled" farm machines.

In the concluding part of his address, Mr. Chambers said that it would be rash to try to predict the progress which would be made in the next quarter-century. It was essential, however, to try to evaluate what was going on to-day, not only in pure agricultural engineering but also in many other engineering undertakings, for a great deal of past progress had resulted from the successful application of other engineering developments to the agricultural machinery industry. As agricultural engineers did not invent or develop the internal combustion engine, Mr. Chambers said he did not anticipate any direct developments by agricultural engineers of gas turbines for tractors, or of the application of nuclear power. Should a power plant be developed for other kinds of vehicles, however, it would be the job of agricultural engineers to apply it to tractors and other farming machinery.

Recent developments in hydraulic transmissions for other vehicles, Mr. Chambers continued, had inspired a study as to how similar transmissions could be applied to tractors. Such transmissions, if successfully applied, would provide many new benefits and would increase the output per tractor and the output per man-hour on the farm. These new transmissions, when they reached the stage when they could be mass-produced, would undoubtedly be more expensive than the present gear transmission, but if they could increase the performance and the output of the tractor, then farmers would be prepared to pay the extra price.

Finally, Mr. Chambers said, one of the biggest development programmes going on in almost every farm machinery company to-day was that of designing and providing machinery for "off-the-farm" use; many existing farm machines could be used off the farm with little or no modification. It was nothing new that farm tractors, with their specially designed equipment, were doing work of a non-farming nature like earth-moving, trench-digging, forestry and municipal work, but what was new to-day was the potential volume for such application. Such business was now over 20 per cent of the total agricultural sales of the U.S.A. and was already having its effect on tractor design. In earth-moving and trench-digging work the task was so severe and arduous that weaknesses showed up early in the life of the equipment, whereas they only appeared after some years of farm work. It would be necessary for the designer of the equipment to improve the revealed weaknesses and that improvement would, in the long run, provide the farmer with more reliable and more efficient tractors. It would, however, be necessary for the designer to be most careful that any improvement he must apply to his machinery for "off-the-farm" use did not unnecessarily increase the cost of his company's agricultural tractors and implements. It so often happened that improvements were no longer economical and, when that occurred, the improvement must only be designed for industrial "off-the-farm" tractors.

# Earth's First Artificial Satellite

*The first artificial satellite to be launched from the Earth rose to its orbit on October 4, 1957. A sphere nearly 2ft in diameter and weighing just over 180 lb with its equipment on board, the satellite was carried by a rocket that is reported to have "flattened out" into the chosen orbit at a speed of almost 5 miles per second. The launching represents the most spectacular contribution yet made to the International Geophysical Year.*

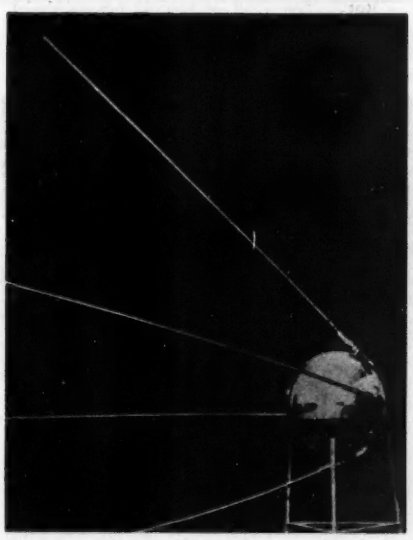
VERY little information on the Russian artificial satellite has so far been released and hardly anything is yet known of the rocket that lifted the device into its orbit on October 4. The satellite itself, dubbed "Sputnik," is reported to be a sphere 58cm in diameter. Made of aluminium alloy, the casing houses two radio transmitters and other equipment in an atmosphere of nitrogen gas, the whole assembly weighing 83·6 kg. Four metal antennæ are attached to the casing: 2·4m to 2·9m long, these rods folded back (as shown in our illustration) when the sphere was on its outward journey. Once established on its orbit, the satellite opened out these antennæ on their swivel joints. While their power supply lasts, the transmitters send continuously (at frequencies of 20·005 Mc/s and 40·002 Mc/s) signals lasting an average of 0·3 seconds; the signal on one frequency is emitted during the pause on the other frequency. The power is believed to be supplied by batteries, not from solar energy. Temperature within the casing is said to be controlled to some extent by forced circulation of the nitrogen, so regulating the thermal "resistance" between the casing and the equipment carried. Sharp variations in temperature tend to arise, of course, because of successive passages through sunlight and the Earth's shadow.

The satellite is visible from the earth's surface only when it is illuminated by the sun, while the earth's surface is in darkness. This is because, relative to the Earth's radius of 4000 miles, the satellite is not high up and visibility only persists for a short period just after sunset and before dawn. The situation is comparable with the observation of a high mountain, whose snows for a short while will be illuminated by the setting sun, when the low ground from which it is observed is already in darkness.

It has been stated in *Pravda* that the signals from the satellite were varied in frequency and timing by the instruments on board according to a predetermined code,* so that readings could be recorded at base for subsequent analysis. One type of instrument that may be carried—going by accounts of Russian exploratory work with high-altitude rockets—is a sensor using piezo-electric plates to detect the number and energy of incident particles. Data on damping may be obtained from measurement of signal level and angles of refraction, and information on the ionised layers in the upper atmosphere may also emerge.

On the actual launching process the same source has little to say. According to the account, the sphere was placed in the nose of a carrier rocket and shielded by a protective cone. Soon after firing, a programming device gradually shifted the course of ascent from the vertical. "At the end of the flight decided on," says the *Pravda* article, "the rocket had reached an altitude of several hundred kilometres and moved parallel to the Earth's surface with a speed of some 8000m per second. After the engines stopped the protective cone was jettisoned and the satellite detached itself from the rocket and began to move independently." Probably a three-stage rocket was used in much the same manner as the Americans plan to use one. The process of launching a satellite with such a rocket was fully described in our issue of August 17, 1956. Another *Pravda* report indicates that launch, guidance and control of the rocket were accurate within a few dozen metres per second of the calculated velocity, and within 1 deg. of the calculated direction of travel.

The orbit is an ellipse with one focus at the centre of the Earth. Dr. D. H. Sadler, of H.M. Nautical Almanac Office, is reported to have calculated the orbit last week from the rather sparse data that was at that time available to him, and the results were sufficiently accurate for optical study to be based on them by the Royal Observatory. Certain of the published Russian figures have been substantially confirmed by this work. According to the account in *Pravda*, on October 9, the plane of the orbit is inclined at an angle of 65 deg. to the equatorial plane, and the trajectory† passes over areas approximately between the north and south polar circles. The plane of the orbit remains unchanged in orientation relative to the fixed stars, and as the Earth rotates on its own axis, the satellite's crossing-over point shifts about 24 deg. along each line



**This, the first official picture of the Russian artificial satellite, shows the device supported in a stand before attachment to the carrier rocket**

of longitude at each appearance over it.‡ The angle of the trajectory to the Equator is not the same as the angle of the orbital plane, since the former is affected by the Earth's rotation. When crossing the Equator to the Northern Hemisphere, the trajectory cuts at an angle of 71·5 deg. in a north-easterly direction, gradually turning east thereafter until it turns south at latitude 65 deg. N. and recrosses the Equator at an angle of 59 deg. in a south-easterly direction. The trajectory reaches latitude 65 deg. S. before veering north again.

The shape of the orbit is expected to change with time, and the satellite is already reported to be slowly descending. The apogee, initially at about 1000km in the Southern Hemisphere, is expected to fall more quickly than the perigee, and the orbit will thus approach more nearly to the form of a circle. More kinetic energy is gained in falling than is lost to atmospheric drag, so that the velocity gradually increases. The horizontal speed of about 29,000km per hour with which the satellite first settled into its orbit will therefore rise, the average radius of the orbit will decrease, and the time per circuit will decline from the initial value of ninety-six minutes. The way in which these changes will occur is one of the important results to emerge from observation of the satellite, as it will provide information about atmospheric densities at its level—it is because the properties of the extremely thin atmosphere at these high levels are unknown that the life of the device cannot be predicted accurately. In announcing the launch, the Russian news agency, *Tass* stated that calculations indicated that the vehicle would burn out when it reached the denser layers of the atmosphere at an altitude of "some dozens of kilometres."

Later (and larger) satellites, a number of which is promised for the International Geophysical Year, are to have a variety of instrumentation covering a wider field of physical measurements. Great attention will be paid (according to one Russian authority§) to recording solar and stellar spectra, &c., and measuring the Earth's magnetic field. Satellites at the present stage of development will not return to the Earth but engineers and scientists are said now to be hard at work on the problem of organising a safe journey home.

* Some authorities have disputed the existence of a code, however.

† That is, the path relative to the Earth's surface which, of course, is not stationary.

‡ This explains the apparent change in the height of the satellite at particular points of observation, since, as already mentioned, the orbit is an ellipse with the Earth's centre at one focus. Depending on the position of perigee, the height observed at stations in this country will be different according as to whether the satellite is northbound or southbound. If there is any precession of the orbit the observed height will be subject to another variation.

§ E. Fyodorov, corresponding member of the U.S.S.R. Academy of Sciences.

## Festiniog Railway

A REPORT received from the Festiniog Railway Company states that at the close of the summer season the number of passenger journeys originating on the railway exceeded 54,000, an increase of more than 15,000 on the previous year, whilst traffic receipts at £3000 showed an increase of some 70 per cent. Further progress was made in clearing the line as far as Tan-y-Bwlch, and, although a test train has reached this point, much track renewal will be needed before a regular passenger service is introduced. It is hoped, however, with the approval of the inspecting officer of the Ministry of Transport, to run regular trains to Tan-y-Bwlch next year. For the first time since 1939 it is proposed to run a winter train service on Saturdays only between Penrhyndeudraeth and Portmadoc.

On the motive power side it is reported that the double engine "Taliesin" entered service and ran over 1000 miles during 1937, and the 0-4-0 saddle-tank engine "Prince" steamed over 4000 miles. The performance of "Prince," which is capable of hauling five bogie carriages, has been improved by the fitting of straight links to the valve gear. It is proposed to rebuild further locomotives as and when funds permit, and the company has acquired an 0-6-0 saddle-tank locomotive from the Harrogate gasworks, which is being modified to suit it to the 1ft 11½in gauge of the Festiniog Railway. This locomotive will probably prove a valuable stopgap in view of the likely extension of the line to Tan-y-Bwlch, and until the second Fairlie "Merddin Emrys" is overhauled.

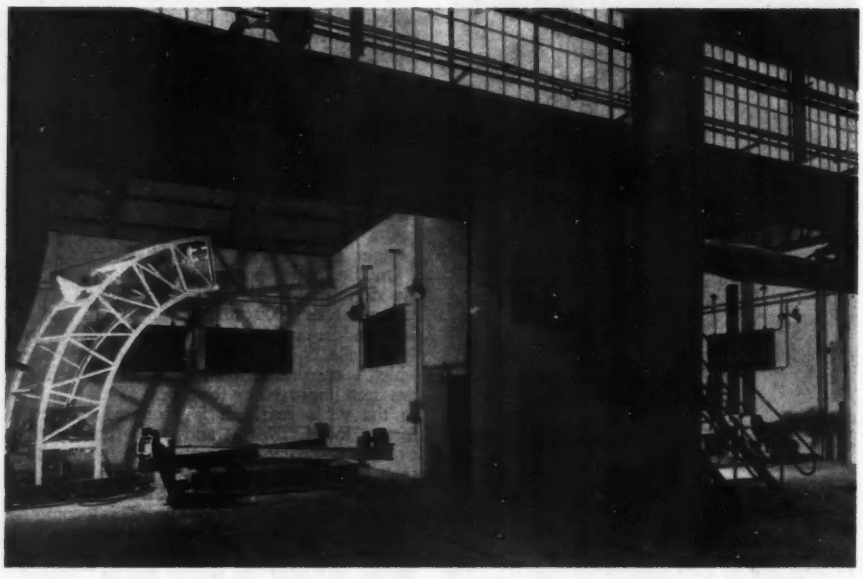
In connection with the signalling, two miniature electric staff instruments have been reconditioned and will be used next year on the Portmadoc–Boston Lodge–Minffordd section. Permanent wiring circuits have been reconstructed as far as Penrhyndeudraeth and a temporary circuit will be installed from this station to Tan-y-Bwlch in 1958.

The society now has a membership of nearly 1000 and its annual general meeting will take place at Portmadoc on April 26, 1958. For this meeting a special train will be run from Paddington, calling at Birmingham, Wolverhampton and Shrewsbury, and it is hoped that members and their friends will have the opportunity of travelling on the Festiniog line as far as Tan-y-Bwlch by a train hauled by the double engine "Taliesin."

RADIOACTIVE COMPOUNDS FROM STOCK.—We learn that the following radioactive compounds are now available from stock at Tracerlab, Inc., Technical Division, 1601, Trapelo Road, Waltham 54, Massachusetts, U.S.A.: 2·4 dichlorophenoxy acetic acid, ring labelled, of specific activity 0·20 millicuries per millimole; 1-naphthalene acetic acid $\beta-C^{14}$, 1·25 mc/mM; 1-naphthalene acetamide $\beta-C^{14}$, 1·25 mc/mM; neopentyl glycol $-C^{14}$, 0·20 mc/mM.

# Fabrication for Nuclear Power Plant

A tour of some of the John Thompson Group companies' establishments at Wolverhampton last week indicated how much had been adapted and extended for work on contributions to nuclear power plant. The top illustration shows domed ends and 18ft diameter rings of 1¼in plate for heat exchangers. Five such rings and two domes make one heat exchanger vessel for the Berkeley nuclear power station. After having their welded seams ground down in this shop, the sections are stress relieved in the new furnace (left background). They are then transported to the site for further assembly. The centre illustration depicts the X-ray bays, with control room between them, which have been built on to the heavy assembly and welding shop. The 18ft rings are moved in on railed trolleys and the welds inspected by gantry-mounted 250kV Newton Victor X-ray sets. The bottom left illustration is taken from a photograph of the high-lift boom Union-melt welding machine installed in an extension of the main bending and welding shop. This machine can weld inner and outer longitudinal and circumferential seams in 18ft diameter shells. With a maximum welding current capacity of 2000A, the equipment is reported to



cater for plate 2½in thick with one pass on each side. Ward-Leonard rotating gears are used for fast setting-up. Below, right, is illustrated a 50ft diameter band of plates 3in thick. This is one of five similar bands to form the cylindrical section of the first reactor vessel at Berkeley. Having been rolled in the heavy bending shop, the plates are mounted in a trial assembly on concrete plinths outside the shop. After dismantling, the plates are transported to the Berkeley site for welding into position. The lower bowl of the vessel has already been constructed, we understand, and the band shown will be joined to it. With the addition of the four remaining bands, the vessel is planned to grow at the same time as the reactor house. When completed it is to be 80ft high and about 1000 tons in weight.

We learn that the nuclear plant facilities at John Thompson's have been provided according to a strict schedule to meet requirements for the building of Berkeley station, due for completion by the A.E.I.-John Thompson consortium in 1961. In addition to work in mild steel for Berkeley, however, the extended facilities provide for other nuclear projects. Instances given include stainless steelwork for Windscale and for the liquid-metal-cooled fast-breeder reactor at Dounreay. It is stated that the nuclear production capacity at John Thompson's works now exceeds that required for the U.K. programme sufficiently for overseas contracts to be considered.

# LITERATURE

**Effective Industrial Management.** By JAMES L. LUNDY. The Macmillan Company, New York, 10, South Audley Street, London, W.1. Price 44s.

THE avowed object of this book is to meet the needs of students in many colleges and universities in the United States for whom an introductory survey in management is a prerequisite for more specialised courses. At the same time, there is much in it which should prove useful to managers and supervisors generally. It is frankly written from an American standpoint, but this need in no way deter British readers, indeed, it is useful to know what is being done elsewhere and so obtain a broader outlook. The field covered is a very wide one, and the thirty-two chapters deal in order with the task of management, its modern background, productivity and the American economy, the fundamentals of accounting and budgeting, the economics of a firm, forms of ownership, business finance, internal organisation, product development, location of plant, equipment and its maintenance, analysis of methods, tools and techniques, measurement of work, materials handling, plant lay-out, plant design, safety engineering, purchasing, inventory control, production control, inspection and quality control, statistical quality control, employee compensation, job evaluation and rating of method, wage payment plans, the acquisition of manpower, development of manpower, collective bargaining, its process, distribution management, and finally a look at the road ahead.

The author points out many defects in present-day practice and makes suggestions as to possible remedies, clearly setting out the work done by such pioneers as Taylor, Gilbreth and Gantt, but he is somewhat hard on what transpires on this side of the Atlantic, boldly affirming that "in the European situation habits of inefficiency are passed down from generation to generation." His outlook is rather coloured by the biographies that are found at the end of each chapter, where there is hardly a reference to any British writings on the various subjects. He has been skilful in taking simple examples from everyday life to explain and elucidate technical problems. The various laws concerning industry are of interest, some of which are designed to ensure competition, and it is noted that the "closed shop" is illegal in the United States.

We are informed that there are five "rights" essential to good purchasing: they are, quality, quantity, time, price, and source. It is surprising to read that "were exact figures on total costs of labour turnover to be known they would probably rock many managers back on their heels," for surely this is one of the points that an up-to-date manager would insist on his cost accountant furnishing at regular intervals, and it obtains in many British factories. Another statement that might well have been suggested by Mr. Lundy as being essential to good management is one showing side by side the estimated cost of an article and its actual cost broken down into material, wages, and factory expense, or on cost.

Among a number of interesting problems discussed are that of timing the introduction of new models, thereby making existing ones obsolete, and of deciding the best layout for a factory, and for the machines employed. We are told that only too often when the layout is being considered that of the office is sadly neglected. Different methods of handling goods are usefully shown by sixty or more photographic illustrations. When discussing the various forms of "employee compensation," or, as we should say, payment of wages, the author does not express any preference for any form of incentive to effort, contenting himself with setting out what he considers the advantages and disadvantages of different systems.

The reader must be prepared for expressions that are not normally used in this country, but he will learn that "soldiering" implies restriction of output, while "featherbedding" means the receipt of pay for which no work has been done, and that the efficient manager will look for a "maximization of output," whereas "the traditional manager is just a player of hunches."

In looking ahead the author suggests that management should be fully recognised as a true profession, and that "even in the face of a high degree of automation, individuals remain as designers, maintainers, operators and managers of automatic systems," and with this in mind the successful manager of the future must be alive to the necessity for applied research, he must approach his problems by a scientific study of them, realising the importance of sound statistical analyses, in fact, rule-of-thumb methods must be entirely eliminated.

It might be mentioned that at the end of each chapter in addition to the biographies already mentioned, will be found a number of useful questions which will readily show a student how much of the subject he has grasped. The whole book has been written in an unbiased way, and has much in it to attract attention, awakening interest in problems that may have been ignored in the past. In conclusion, the author claims that "progress toward better living through better management has just begun." In the words of Abraham Lincoln, "it is for us, the living . . . to be dedicated here to the unfinished work."

**The Measurement of Soil Properties in the Triaxial Test.** By A. W. BISHOP and D. J. HENKEL. Edward Arnold, Ltd., 41, Maddox Street, London, W.1. Price 70s.

THE constantly increasing use now being made of the science of soil mechanics and the consequent provision of testing equipment not only in central research institutions but also in the offices of civil engineering consultants and contractors justifies alone the appearance of this book essentially intended for the laboratory worker. Both the specialist and the novice in the field of soil testing will find much of interest in this publication. To the designer an added appreciation of the meaning of the data obtained from the triaxial tests will prove valuable. As pointed out by the authors in the preface, the work is largely based on the methods and apparatus developed by them at Imperial College. The excellent bibliography and frequent reference in the text to the work elsewhere in this country and abroad, however, provide the reader with a comprehensive and up-to-date picture of the field of quantitative testing of strength properties of soils.

The triaxial testing technique has in recent years become one of the main tools in providing the quantitative data used in stability analysis. The versatility of the test, by which a wide range of stressing conditions can be achieved allows the soil to be tested under circumstances similar to those obtained in the prototype and eliminates many of the uncertainties with which the designer is always faced. Data on compressibility and consolidation obtainable in the tests allow the apparatus in some cases to supersede the usual oedometer equipment.

The book is divided into four parts. The first deals with the general principles of the tests and with the range of data obtainable from these. Within the limits of the volume it is obviously difficult to give more than a bare summary of the theory involved and of its application, and the reader therefore is assumed to be conversant with the essentials of soil mechanics and its terminology. The remaining three parts of the book deal at some length with the apparatus and the tests to which it can be applied. Excellent photographs and diagrams make this text easy to follow. The range of apparatus illustrated and the description of its characteristics should allow suitable choice to be made for most conditions. A somewhat unusual practice of presenting a list of the suppliers of the various parts of equipment is followed by the authors. This, however, is commendable, as often a new worker entering a field of research finds that a large amount of time and energy is consumed in tracing a source of supply of some, apparently trivial, part of apparatus.

The general presentation of the book is good and the numerous diagrams very clearly printed. Perhaps the excellent printing, coupled with possibly a narrow market, accounts for the price which appears rather high for a book of this size.

**Diesel Fault Tracing, Maintenance and Repair.** By STANTON ABBEY. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 16s.

THIS is the second edition of the book and is a practical manual dealing with high-speed diesel engines, including those used for transport, tractor, marine and stationary purposes. There are twelve chapters, each of which deals with the various engine parts and systems, such as fuel supply, lubrication, cooling. Diesel principles are dealt with and there are general notes upon maintenance and fault tracing, followed by problems relating to the servicing of fuel injectors, fuel pump maintenance and the fuel system. Other chapters deal with engine governors and lubrication, also questions concerning decarbonising, top overhauls and major overhauls, while attention is paid to curing cooling system defects, details of engine auxiliaries, and the electrical equipment. To assist in the rapid and accurate tracing of faults the book includes ten systematic diagnosis charts, which, besides their primary duty, serve to convey a considerable amount of information.

## Books Received

*Factory Organization and Management.* Seventh edition. By T. H. Burnham and D. H. Bramley. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 25s.

*Typical Microstructures of Cast Metals.* Edited by G. Lambert, The Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester, 3. Price 84s.

# International Motor Show

No. I

THIS year's International Motor Show, the forty-second of its kind arranged by the Society of Motor Manufacturers and Traders, was officially opened last Wednesday, October 16, by the Prime Minister, Mr. Harold Macmillan, and once more the Earls Court Exhibition Hall at London has become the focal point of interest for all concerned with the motor industry. Scheduled after the recent big motor exhibitions at Frankfurt and Paris, the show may appear an anticlimax for a number of foreign buyers and experts who habitually visit those international trade fairs, as most of the latest British models have already been presented at the previous shows. For the general public, however, the show affords an unequalled opportunity to compare, under ideal conditions of presentation, the respective merits of the many vehicles sent from home and overseas. Among the British exhibits there are, obviously, a considerable number of familiar models, the design of which, being regarded as fundamentally sound, shows no change since last year's motor show, while others have been modified and improved. Generally speaking, the 1957 show does not display any marked change from previous styles, nor are there any remarkable or novel technical innovations. Development seems to be mainly concerned with coachwork changes and improvements in styling, while mechanical changes are limited to the usual modifications of major components and to accessories made by proprietary firms.

It must be emphasised, however, that this lack of original ideas and ingenious constructions has been apparent at most of the recent international motor shows, especially those which are held at annual intervals. Apart from the fact that a design, once established, has to be maintained more or less unchanged for several years, there is another factor which has contributed to this lack of novelty. It is the habit of most manufacturers to-day to bring their new models out when they think fit and not to wait for a settled date such as a major motor show. The object of this policy is to maintain full employment in autumn and stabilise sales and deliveries. Reasonable as this attitude may be, it tends to change the character of a motor show from a major event of technical interest to a trade fair, with a corresponding loss of public appeal. It would be wrong to conclude from these remarks that such a state of affairs seems to be imminent yet ; on the contrary, to judge from the number of visitors attending the show on the first two days, it can be safely assumed that the comparative study of motor cars, irrespective of whether or not they have been previously examined, is still an object of major interest.

This year's exhibition has some significance, as it is the tenth post-war Motor Show, the first after the war taking place from October 27 to November 6, 1948. It might be worth while in this connection to give a brief survey of the progress in technical as well as in economic respects which the British motor industry has made in the past ten years. It must be remembered that the position of the industry in 1948 was very strong indeed ; the end of the war had left the Continental motor industry in a state of almost complete disintegration, and British and American cars were the only makes available for immediate export to the world's markets. Since the end of the war the British motor industry, which before 1938 mainly catered for the domestic market (an average of 20 per cent were exported only) had been vigorously engaged in satisfying this demand and, particularly, the special requirements of overseas customers. The first post-war years were a period of intense technical activity, almost entirely intended to modernise the out-of-date pre-war designs and bring them in line with the standards generally associated with the American and Continental schools of automobile engineering. These years saw the introduction of the modern full-width body style with sensible, well-placed air intake louvres, recessed head lamps, and—the most important change in the recent history of British automobile design—the almost general acceptance of the independent front-wheel suspension in conjunction with frictionless springs. Other modifications, some of which might well be considered as fashion trends, were front bench seats in small cars, not wide enough anyhow to accommodate two passengers next to the driver, and the associated acceptance of the steering column gear control. By these means and by an intensive reorganisation of the production process, the British motor industry at the time of the first post-war show had achieved the remarkable feat of exporting about 400,000 motor-cars, representing a value of more than £100,000,000. Production was running at the rate of 345,000 cars per year, of which 75 per cent, about 20,000 per month, were exported. This prosperity continued with only slight fluctuations until 1952, reaching its peak in 1950, in which year, out of a production of 522,000 cars, about 398,000, i.e. 76 per cent of the total production, were sold abroad. During this period the industry was working under most favourable conditions, induced through the worldwide dollar shortage, the lack of competition from the Continent and, further, the devaluation of the pound in 1949, which greatly stimulated exports to hard-currency countries.

It was obvious that, with the re-emergence of France, Germany and Italy as major motor-producing countries, the dominant position of the British motor industry would be partly lost. This was indeed the case; while production in this country was still rising, exports dropped gradually and since 1953 have been more or less constant at the rate of about 50 per cent of the total output. Up to the middle of 1955 the industry had no difficulties in selling in the domestic market every car not scheduled for export. In this period of a seller's market the manufacturing capacity of our motor factories was actually insufficient to satisfy the demand ; a vast expansion and modernisation scheme, involving a very substantial capital investment, was successfully carried out, thus greatly increasing the industry's potential capacity. In the autumn of 1955 the demand, at first in the domestic market and, later on, from overseas, began to slacken, and eventually developed to a definite recession in 1956, when the production dropped from the 1955 record of 897,000 to 707,000 cars (i.e. by 20 per cent) and exports from 390,000 to 337,000 cars (14 per cent). The reasons for this drop in production are sufficiently known and can be broadly derived from political difficulties (Suez crisis) and from such domestic causes as labour disputes, "credit squeeze" and restrictions on hire purchase. The reasons for the drop of exports are less easily defined, but they were due to a great extent to the steadily growing competition of German, French and Italian manufacturers, who, with some particularly efficient or otherwise attractive models, had made considerable inroads into markets formerly held by this country.

The present situation is still rather unsettled, but after several months of stagnation early this year production as well as exports are showing a rising tendency. In the first eight months of 1957 production figures have gone up to 510,000 cars, compared to 490,000 in the same period last year (an increase of 4 per cent), and exports from 225,000 to 278,000 cars, i.e. by 23 per cent. Sales to the European Continent in this period have been well maintained or even slightly increased, while a reduction of exports to Australia has been more than compensated by an increase of sales to U.S.A. from 20,000 in 1956 to 59,000 cars this year. The American market with its demand for light and handy small cars is becoming more and more important and, at present, U.S.A., buying more than 35 per cent of her total car imports from this country, is indeed Britain's best overseas customer.

Whether these most encouraging results of the last few months will be maintained will depend mainly on the development of the economic situation—in particular whether it will prove to be possible to check the steadily rising prices of essential raw materials and to deal effectively with future new wage claims. A contributory, though not less important factor, and one for which the industry alone has to accept the responsibility, is the question whether our latest models represented at the show will be able to attract by their eye appeal, their technical specifications and last, but not least, by their price, foreign buyers more strongly than the equivalent cars of our Continental competitors.

In this respect the British motor industry is almost wholly optimistic ; it is confidently expected that, after the series of setbacks in 1956 and in the first months of this year, the present show will prove to be an important step forward on the way to recovery and will help to regain Britain's former position as the world's leading exporter of motor-cars. There seems to be some justification for this optimism, as Britain has recently regained her position from Germany as leader in the imported car market in the U.S.A. In this market the big American-controlled British firms, selling through the sales organisations of their parent companies, are doing particularly well. Another promising omen was mentioned by the president of the S.M.M.T. at a recent press conference : while German car exports exceeded British ones by 32,000 in the first four months of this year, this situation has now changed and, in the period between May and August, British overseas sales actually surpassed German exports by 2000 units.

Whether this impressive recovery has, as some economists believe, been due to the monetary situation, i.e. to the scarcity of the German D.Mark and to the weakness of sterling in foreign exchange markets, is difficult to decide. These factors may have had some influence, but we believe that the well-styled models now produced by several manufacturers, the availability of better service facilities abroad and, generally speaking, a more aggressive sales policy, have contributed to this success.

## Current Trends

The first impression when visiting the Motor Show is, as usual, the gaiety and colour of the display presented by the record number of 310 cars which are exhibited by thirty-four British and thirty-five American and Continental motor manufacturers. In view of the international character of the show, it is difficult to discern one general trend which might point out the direction in which automobile development all over the world is likely to progress. On the contrary, this year's show seems to emphasise more than ever before the differences existing in the British school of automobile engineering and those of America and the European Continent. It is quite true that American as well as Continental influences have left their impression on the design of the British post-war car, in particular on its styling. In mechanical layout, however, the modern British car differs from the less advanced new models of the first post-war exhibition ten years ago, not so much in its overall conception, but mainly in the greatly improved design of major components and accessories. This conservative policy once more confirms the strong belief prevailing in the British motor industry that substantial progress can just as well be achieved by steady evolutionary development as by revolutionary innovations.

Assuming the validity of these assumptions, it is no matter of surprise that most of the cars making their first public appearance at Earls Court this year (some of them already introduced in the first months of this year) show no radical changes in design, and that such alterations as, for instance, the use of smaller road wheels, have actually been overdue for some time. The annual "freshening up" of models generally concerns minor features of the coachwork and the accessories, with slight mechanical modifications only. The more drastic changes in body styling, displayed at the show, are obviously influenced by American fashion trends, characterised by still wider wrapped-round

"panoramic" windscreens, larger curved rear windows, and by the long-flowing lines resembling stabilising fins at the rear wings. Excessive ornamentation of some of the *de luxe* models is another of these fashion trends, though it must be admitted that some of the latest creations of the modern body stylist are more restrained in this respect.

With respect to mechanical modifications it is to be mentioned that the compression ratio of engines has generally been raised—a ratio of 8 : 1 is quite common nowadays—to make use of higher octane petrol. The effect of this modification on the engine performance is difficult to assess, as many firms prefer to specify the output in brake horsepower only, without giving any indication whether this refers to the "net" horsepower, actually available at the clutch, or to the about 10 per cent higher "gross" horsepower of the engine without such accessories as generator, radiator fan, water pump, silencer and air filter.

Intensive activity is taking place in the field of transmissions, but—apart from a few exceptions —most of the development work is being done by firms specialising in making automatic and overdrive units or clutches with fluid, electromagnetic or centrifugal coupling action. Most cars of more than 2·5-litre engine capacity are now optionally available with a fully automatic transmission, as a rule of the Borg-Warner type, while several small and medium-sized cars can be equipped with centrifugal clutches having a vacuum-operated withdrawal mechanism, operated by remote control from the gear lever. It appears that this latter, reasonably priced system satisfies the demand for a comparatively simple two-pedal control system suitable for the most popular range of cars, i.e. those between 1 and 2-litre cylinder capacity. So far no reliable statistics are available to indicate the proportion of cars already fitted with these semi-automatic gear-shift helps, nor do we know how they have been behaving in prolonged arduous service operation. There have been teething troubles, of course, but these apparently have been overcome, and it can be expected that automatic clutches will sooner or later become standard equipment in cars unsuitable for fully-automatic transmission.

The expectation, frequently expressed in the last four or five years, that the disc brake would sooner or later replace the shoe brake, has not been fulfilled. Though valuable improvements have been made, in particular in respect to self-adjusting friction materials and linings of better wear resistance, the application of the disc brake has been, and is still, confined to fast cars in the higher price bracket. In these cars the disc brake has proved very successful ; on the other hand, it must be conceded that the shoe brake is still capable of improvement, and Continental designers maintain that this type, especially when equipped with finned cast-iron-lined light-metal drums, cooled by forced draught, is by no means inferior to the disc brake.

After a general survey of the principal trends in British automobile engineering, we now turn to a description of some of the latest British models and of such foreign cars which are either displayed in this country for the first time or differ considerably from their British counterparts in general layout and detail design.

The greatest floor space in the Exhibition Hall is occupied by the firms belonging to the British Motor Corporation. Most of the thirty-eight models exhibited by these firms have remained unchanged or have minor modifications only. The Austin "A55" introduced early this spring

**The Vauxhall "Cresta" resembles the "Velox" in outline**

is sufficiently well known ; it differs from its predecessor "A 50" only by a higher output of the 1·5-litre engine, due mainly to the increase of the compression ratio from 8 : 1 to 8·3 : 1.

At the stand of Wolseley Motors, Ltd., is shown the type "1500," a car closely related to the Morris "1000." The car is unusual in having the relatively high final drive ratio of 3·7 : 1, and the gear ratios permit speeds up to 75 m.p.h. in third and 80 m.p.h. in top gear.

Following its introduction this August, a new 2·6-litre Riley is making its first London Show appearance at the stand of Riley Motors, Ltd. The model is in many ways similar in appearance to the four-cylinder, hemispherical-head 2·44-litre "Pathfinder," which it replaces, but is fitted with a six-cylinder, 2·6-litre B.M.C. engine, specially adapted for this car. The engine has twin S.U. carburettors, a compression ratio of 8·3 : 1, and develops 100 h.p. at 4750 r.p.m. Optional extras include either a Borg-Warner overdrive or a fully automatic transmission of the same make. Servo-assisted brakes give a superior stopping power with a minimum of effort. The suspension employs torsion bars at the front and semi-elliptic springs with inclined telescopic dampers at the rear.

Looking at the numerous models made by the British Motor Corporation, one is inclined to marvel at the ingenuity shown by the group in pooling their main units and components. The great majority of the thirty-eight models made by the B.M.C. are actually equipped with three basic engines only, a 1-litre and a 1·5-litre four-cylinder, and a 2·6-litre six-cylinder, the latter having the same stroke but a larger bore than the 1·5-litre engine. According to the purpose and to the characteristics of the car they have to serve, they are alternatively fitted with one or two carburettors and correspondingly varied inlet manifolds ; there are also variations with regard to some accessories and to the position of the petrol delivery pump. By varying the compression ratio and the engine speed, it has been possible to adapt these engines to fit most of the models built by the Corporation.

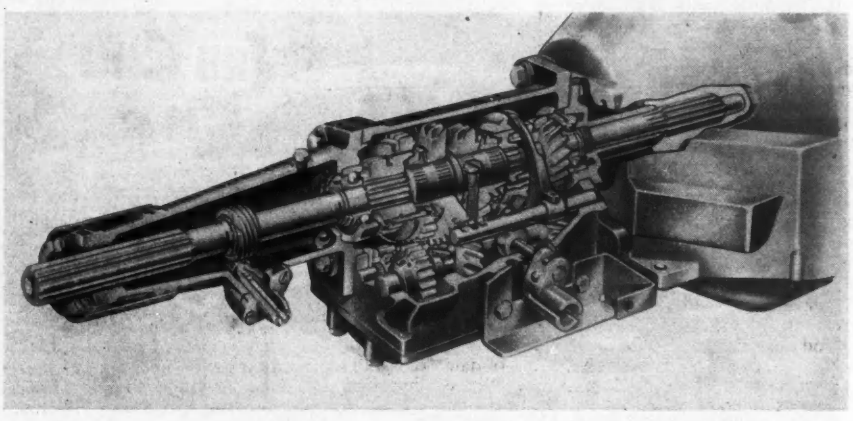
By the same process of standardising the design of other major components like gearboxes and rear axles for practically all B.M.C. vehicles, considerable savings in cost and great simplification of the manufacturing process have been effected. Indeed, it can be said that only by this method has the group been able to offer at a reasonable price such a variety of models of greatly differing character.

A similar method of pooling not only such major components as engines and transmission units, but also the whole or parts of the body structure, is employed by the Rootes group. Here the 1·4-litre four-cylinder engine of the "Minx" of Hillman Motor Car Company is also used in a "hotted-up" version for the higher-performance "Rapier" car of Sunbeam Talbot, Ltd. Also, the body of the "Rapier" saloon is almost identical with that of the "Gazelle" of Singer Motors, Ltd., while the 1·5-litre overhead camshaft engine is still of the original Singer design.

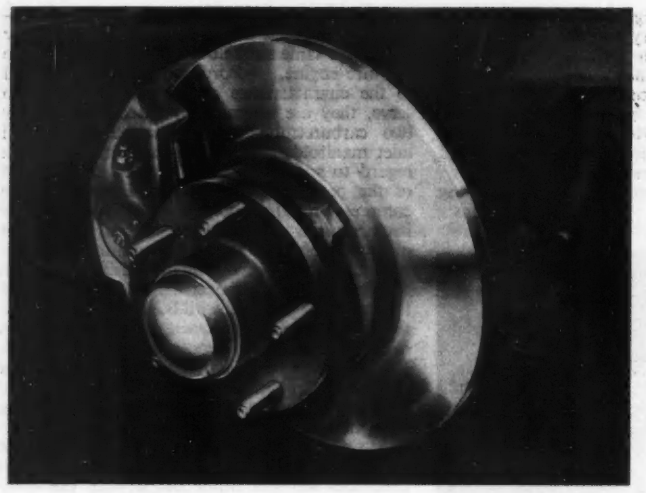
The "Vanguard" of Standard Motor Company, Ltd., remains virtually unchanged, apart from new gearbox mountings and modifications to the suspension which have reduced road noise and vibrations. The 1958 model is lower than its predecessor, as the former 16in wheels have been replaced by 15in wheels.

There are two new additions to the Standard range : a new four-cylinder, 1·67-litre car, "Ensign," and a restyled 950cc small car, "Pennant." The "Ensign" in outline and styling is similar to the "Vanguard," but has a four-speed gearbox with a central gear lever as opposed to the three-speed gearbox with steering column control of the "Vanguard." The new gearbox is the same as that fitted to the Triumph "T.R.3" sports car made by the Triumph Motor Company, the sister company of Standards. The 1·67-litre four-cylinder engine of the "Ensign" has the same stroke of 92mm as the 2-litre "Vanguard" engine but a smaller bore (76mm instead of 85mm) and, with a compression ratio of 8 : 1, develops 60 h.p. at 4000 r.p.m. Apart from the above-mentioned features, most of the mechanical layout is similar to that of the "Vanguard."

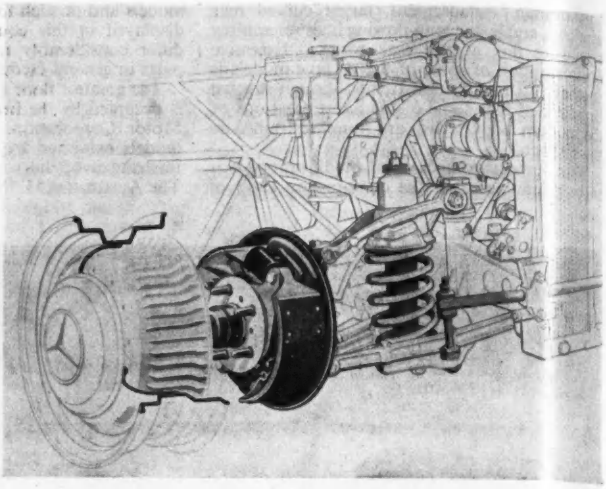
The Standard "Pennant" is a restyled version of the Standard "Ten," powered by basically the same engine, which, at the increased compression ratio of 8 : 1, now develops 37 h.p. at 5000 r.p.m. The central gear lever has been shifted to the rear and operates the gear shift by an interposed linkage. As with the 1958 models of the Standard



**The six-cylinder Vauxhalls, like the "Victor," have synchromesh and helical gears for all forward ratios**



The Lockheed disc brake has now dispensed with external piping between the opposed cylinders, and incorporates positive continuously adjusted running clearance



The drum brake has continued to develop, and on the Mercedes "300 S.L." positive circulation of cooling air across the drum is provided when the wheels are rotating

"Eight" and "Ten" saloons, the rear seat folds forward and gives access to the boot from the inside of the car in addition to the exterior access.

After marketing the 1·5-litre "Victor," last March, it was to be expected that Vauxhall Motors, Ltd., would follow up with a new six-cylinder car to replace the former "Velox" and "Cresta" models, which have already had their engines modified to correspond with that of the "Victor" rather than the "Wyvern." It had been clear for some time that these models, the basic conception of which dates back some ten years, no longer conformed to present ideas of modern body styling and that the design had to be reconsidered with a view to bringing it entirely up to date. Vauxhall Motors, Ltd., has used this opportunity to discard its former practice of providing two models of widely different performance by making one body shell to accommodate two engines of different output. This method, though quite effective in keeping the cost of production low, had actually prevented the firm for some time from building really well-proportioned vehicles designed in complete harmony with their engines.

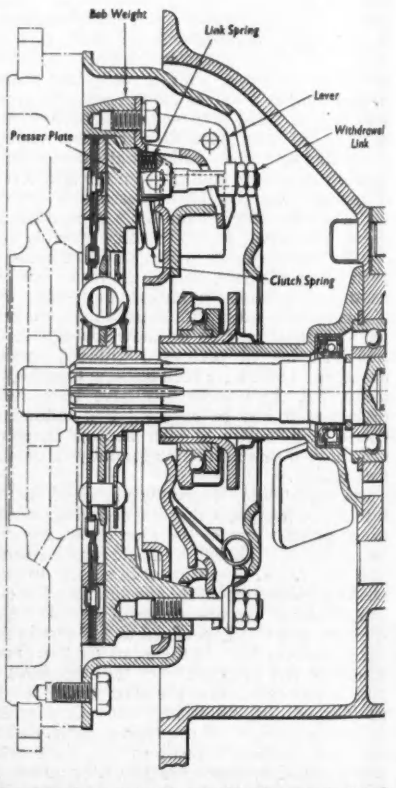
The present "Victor," which replaces the old "Wyvern," and the new "Velox," as well as the *de-luxe* version "Cresta," do in fact overcome this disadvantage; they are different in size and designed to accommodate one specific engine. The engines of the new cars have the same bore and stroke as those they replace, and there are also similarities in the design of the transmission and suspension units. As the "Victor" has been known for some time, we might usefully limit our report to a description of the "Velox," the more as the design principles of the major mechanical components are practically identical. The new "Velox" is built, like its predecessor, in integral construction; it has a greatly increased torsional stiffness and is designed to resist severe stressing without distortion. In appearance the car is entirely different from the previous model; there is more entrance space and much wider seats, front and rear, and the stylists have combined a low, sweeping roof-line with considerably more headroom than in the previous model. The panoramic windscreen brings the front pillars entirely out of the line of vision and the full-width rear window, together with the low bonnet, make parking easy, for all four corners of the car can be seen from the driving seat. There is ample room for luggage, as the spare wheel is mounted in a special compartment beneath the boot.

The engine retains such useful design details as the short stroke and the chromium-plated top rings, but it has now individual inlet ports, larger inlet valves and, further, off-set gudgeon pins to prevent piston slap. It has a compression ratio of 7·8 : 1, an output of 82 h.p. at 4000 r.p.m., and a "Zenith" carburettor having an automatic choke. A valuable improvement is the incorporation of a synchronised bottom gear in the three-speed gearbox, a feature which is likely to simplify traffic driving considerably.

The brakes are amply dimensioned: the drum diameter is 9in, as before, but the linings are wider, so that the total lining area has gone up by 37 per cent. In order to prevent the tendency of wide brake drums to "bell-mouth" because of the rigid connection between brake path and hub, the cast iron brake drum is attached to the hub by a cast-in pressed steel corrugated diaphragm which does not constrain the drum radially. In contrast to the brakes of the Ford "Three Graces," torque is transmitted directly from the wheel to the shoe path by three dogs cast in the drum. The rim of the drum is nearly symmetrical, and the design clearly aspires to the freedom from thermo-elastic effects of the disc brake.

In order to reduce drumming of the integral body structure, the entire under-surface, except for the front wings, is coated with a thick layer of rubber-plastic material. All bright work above the waistline, except for the no-draught

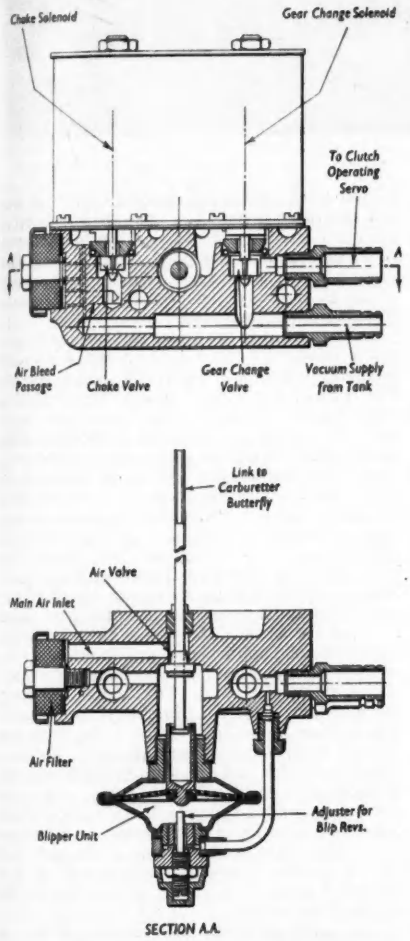
The "Zephyr" Mark II has now returned to the air intake made familiar by the Mark I cars




Provision is made in this centrifugal clutch for it to be engaged when the engine is stationary: actuation of the mechanical withdrawal mechanism (bottom) allows the spring-loaded links to free themselves from the levers (top)

windows and the heater air intake (which are chromium-plated), are made of stainless steel.

Changes in the models displayed by the Ford Motor Company, Ltd., are not limited to outward appearance, although such changes have been made, as can be seen in the illustration of a Mark II "Zephyr." Restyling of the 1172 c.c. cars has, perhaps surprisingly, affected not the "Popular" but the integral construction models, the "Anglia" now having a lattice grille that bears the same relation to that of a Mark II "Consul" as the "Prefect" grille does to that of a Mark I "Consul." The mechanical changes are not obvious, but interesting; on the larger cars recirculating-ball worm steering gear replaces the worm and peg mechanism. Considerations of space available led to a ratio of 18·0 : 1 instead of the former 16·8, and the steering effort is further lightened by the higher forward




**The control mechanism for vacuum disengagement of the centrifugal clutch makes provision for progressive engagement in two stages, and for rapid closing when the throttle is open**

efficiency of the gear. The efficiency is not extreme because, to reduce the reverse efficiency, a friction brake is included. On the smaller cars the hydraulically operated clutch can optionally be replaced by a semi-automatic clutch, which engages automatically for starting from rest and under the driver's control for gear changing. The clutch is of an unusually advanced conception, incorporating, as it does, provision for hand engagement to allow tow starting, and it may be easier to follow the principle of operation if reference is first made to the basic Newton design illustrated on page 472 of our account of the previous Show (October 5, 1956). The Ford clutch is illustrated on page 564, and it can be seen that instead of studs fixed in the pressure plate it has links pivoted to move in the radial plane. These links, when not engaged on the levers, move under the influence of centrifugal force and a small compression spring, which can be seen in the heel of the link. If, therefore, the clutch thrust is advanced to lift the presser plate mechanically, the links will remain in engagement with the levers if the engine is running, but if it is stationary the links will move inwards and allow the clutch springs to close the clutch completely. There is a cable and a handle attached to the vacuum servo clutch withdrawal gear, and by pulling and releasing this when the engine is stationary the driver can engage the clutch to perform a towed start. The links can be re-engaged with the levers, to render the clutch again centrifugally responsive, by raising the engine speed to about 1000 r.p.m.: centrifugal force causes the levers to move forward, under the influence of the bob weights, and the links outwards. The travel available to the vacuum servo is limited to prevent the links disengaging when the withdrawal mechanism is moved under automatic control.

The control gear for the vacuum system bears some resemblance to that attributed to the Ford "Taunus" M.17 in our issue of September 27 last, page 468. As the illustration alongside shows, it includes two electric solenoids, the "choke" and the "gear change" solenoids; vacuum from a reservoir is led to the upper face of the "choke" valve and the lower face of the "gear change" valve. (This reservoir is separate from that for the wiper motors). The lower face of the "choke" valve communicates with an air bleed, and the upper face of the "gear change" valve with the central tunnel leading to the air valve on the throttle link. The "choke" valve chamber communicates with this tunnel also, while the "gear change" valve chamber is connected to the servo motor. Both valves are spring loaded down, and the "gear change" valve is down in all circumstances except when the driver's hand rests on the gear knob, which includes a wobble switch: in that case the vacuum reservoir is placed in direct communication with the servo cylinder and the clutch is disengaged. The normal running condition for the "choke" solenoid, however, is energised, as drawn: the "choke" valve drops only when the engine speed, as detected by a relay in the generator circuit, is low or when the starting carburetter is in use (or both). Either of these conditions allows air to be drawn from the servo motor, through the central tunnel, up the "choke" valve and down a small bore to the vacuum supply (the bleed is closed off in this case): because of the restriction between the reservoir and the "choke" valve, opening the throttle and thereby the air valve will allow the clutch to re-engage and the car to be driven off. It can be seen that the air valve stem is connected to a small vacuum servo motor: this acts to open the valve, and hence the carburetter throttle, when the clutch servo is activated other than by the "choke" valve (when the "choke" valve is up the two sides of the blip servo are in communication) and thus keeps the engine speed at 1800 to 2000 r.p.m., well above the centrifugal clutch engagement speed. The normal engagement of the clutch takes place in two stages: rapidly by admission of air through the air valve until the servo pressure is low enough for a spring to pull the carburetter link closed, and then slowly by bleed through the underside of the "choke" valve. The setting of the spring on the linkage is therefore critical, and is carried out by the interesting technique of standing the car on a level surface with the brake off and engaging first gear: the engine speed is raised by the foot throttle to lift the "choke" valve and the blip servo then increases it to about 2000 r.p.m. When the gear knob is released the servo mechanism will engage the clutch and force the engine speed down, so causing the bob weights to free the clutch again: the correct setting causes the car to move forward 1ft in the process.

The electrical system needed for this two-pedal installation has been extended to include electric starter-motor control: a micro-switch mounted on the gearbox detects movement of either selector, and does not allow the starter solenoid to be energised unless neutral is selected.

*(To be continued)*

## Superheater Works

THE guests who recently attended an "open day" at the Trafford Park Works of the Superheater Company, Ltd., were shown the firm's production methods and some of the work now in hand for power plants in many parts of the world. A further point of interest was the progress which has been made with a comprehensive programme of extension and plant rearrangement at the works. The company was founded in 1912 and the works, which were opened in 1914, have grown from two relatively small bays to a factory area of 16 acres, 14 of which are covered by works buildings with fifteen main production bays. The principal products include steam superheaters, reheaters and desuperheaters for all classes of locomotive, marine, power station and industrial plant boilers. Indicative of the development in steam plant is that designs are being contemplated for power stations having an evaporation of 3,900,000 lb per hour at a pressure of 2400 lb per square inch and a temperature of 1055 deg. Fah. This compares with plant of twenty years ago when an evaporation of 250,000 lb per hour at 650 lb per square inch and 800 deg. Fah. was considered high.

The most recent addition to the works is a new shop comprising two bays, each 420ft long by 80ft wide, in which the whole of the productive capacity for the manufacture of locomotive superheaters has been installed. The shops previously engaged in this class of work are in process of reconstruction and re-equipment to provide increased productive capacity for the manufacture of large industrial power plant equipment, which now includes components for nuclear power installations. Each of the new bays is equipped with one 10-ton and one 3-ton overhead crane, and in anticipation of future requirements the crane gantries have been designed to take 20-ton capacity cranes.

Under the progressive production sequence laid down for the new shop the tubes required for the superheaters are stocked at the foot of one bay. These tubes are built up into components as they pass up the length of the bay across the top and down the adjoining bay, where the then completed superheaters are packed ready for despatch. In the process of manufacture the individual tubes are first ball-ended, trimmed to length, welded into pairs, assembled in groups, headed and strapped with spacers; hydraulically tested, and finally dropped in a protective composition before being packed for despatch. At each stage every element undergoes a thorough inspection before being passed on for the next operation.

For the various processes involved in building superheaters the firm has installed a range of specially adapted bending, forming, welding and other equipment. Welding techniques play a particularly important part in the making of modern superheater equipment and the plant installed includes that for no less than nine different welding processes. The necessity for this range of processes will be appreciated from the fact that the materials handled include iron and steel castings, steel forgings, billets and tubes of all kinds and qualities, from mild steel to the high alloys. Inspection is also of particular importance and, in addition to visual checking at all stages of production and hydraulic pressure tests, X-ray and gamma-ray plant installed can be used for detecting flaws in steel up to 2in thick. Although comprehensive equipment is a key to successful production in the works, the visitors on this open day were able to see how a high degree of skill on the part of operatives is also essential, particularly in the making of large individual equipment for power plants. This equipment is made to special requirements and to maintain the close tolerances laid down considerable skill and care is required in producing long tubular assemblies, incorporating multiple bends and curves, which are to be subjected to high steam pressures and temperatures in service.

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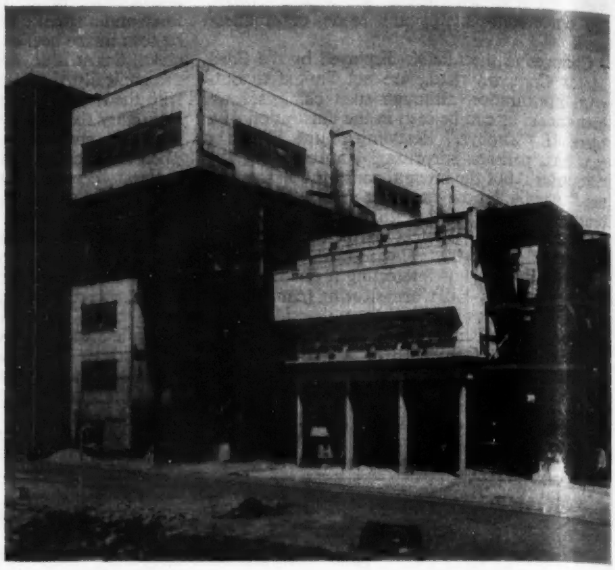
COIL WINDING MACHINE.—A bobbin winding machine capable of accommodating thirty reels of 4½in diameter and wire from 20 to 46 s.w.g. is being made by Westool, Ltd., of St. Helen's, Auckland, Co. Durham.

# Ince Power Station



*Opened on October 9 by Lord Citrine, Ince power station is one of sixteen that it was decided at national level to adapt for oil firing. Built on an "island" in drained marshland, the station is supplied with water through 8½ miles of pipeline and has a generating capacity of 240MW. The power demand of the Capenhurst atomic factory was the original justification for the erection of the station. Equipped with semi-outdoor boilers, as shown in the adjacent illustration, the station has an overall efficiency of about 29·1 per cent which is believed to be the highest in the North West, Merseyside and North Wales Division.*

INCE power station, in the North West, Merseyside and North Wales Division of the Central Electricity Authority, was officially opened on Wednesday, October 9, by the chairman of the Authority, Lord Citrine. The station has a total capacity of 240MW from four 60MW turbo-generators.

At the end of 1949 it became apparent that the future power demand of the atomic factory at Capenhurst—owned then by the Ministry of Supply and now by the United Kingdom Atomic Energy Authority—made the construction of a new power station in the Wirral peninsula of Cheshire essential. A site was therefore sought within the areas specified by the Ministry of Supply. The location chosen is on the edge of the Ince marshes, near Elton village, and immediately to the north of the Frodsham–Ellesmere Port railway. An unusual outline was adopted to avoid interference with agriculture.

As a result of a study of some aspects of American boiler design by the Authority, it was decided (in view of the need for both speed and conservation of building material and labour) that the boilers should be a compromise between a completely outdoor arrangement and the conventional boiler-house.*

Ince is one of sixteen power stations which it was decided at national level to adapt for oil firing. The construction of the station was well advanced when it became apparent that the country's future power requirements could not be obtained solely from coal, and investigations were therefore made at a number of power stations on the possibility of adapting boilers for dual firing, i.e. burning heavy fuel oil as an alternative to pulverised coal. At Ince, as at other stations, conversion was found to be practicable and the additional plant and equipment was planned.

The supplies of water, both for boiler and cooling tower make-up, are pumped from the River Dee at Chester through a pipeline constructed specifically for Capenhurst, Ince power station and industrial development in the Ellesmere Port district. The water scheme has been provided by the West Cheshire Water Board and has entailed participation in the Bala Lake scheme. A reservoir is under construction on the high ground at Ince village for emergency water supplies in the event of a failure of the normal make-up quantity. Coal is delivered to the station by rail, normally from the East Midlands coalfields, and large sidings with a coal storage area have been provided on the site.

Approximately 83 acres of land were acquired to accommodate the station, and, as a result of trial borings, the main buildings were located where the load-bearing sandstone approached its highest level. After the removal of 14ft of top soil and other material, it was possible to erect the main buildings directly on the hard bound sand, thus eliminating piled foundations. The cooling towers and the north chimney did require piling as the sandstone formation falls away sharply from the main site.

The basement to the boiler and turbine houses has a reinforced concrete floor and reinforced retaining walls, all externally waterproofed. The reinforced concrete culverts for circulating water are beneath the turbine house floor level, and the reinforced concrete turbo-alternator blocks are independent of the main superstructure. The four cooling towers are founded on reinforced concrete piles in the peat subsoil, as is the north chimney; the south chimney has a mass concrete foundation. The two circular chimneys are of brick and are 300ft high. The main buildings are steel-framed constructions. Sheet cladding on the boiler-house permitted the use of lighter steelwork than would have been required for brick. Measuring 350ft by 232ft, the whole main building contains about 3800 tons of steel. The parts of the boiler-house which are enclosed are clad with "Cellactite" sheeting the minimum amount of brickwork being used. The turbine house is of brick. The roofs are formed from asbestos cement cavity decking, covered with felt laid on an insulating layer, and finished with light-reflecting stone chippings. All the suspended concrete floors in the station are of steel filler beam construction. Aluminium faced doors have been provided in the west wall of the turbine house for withdrawal of the generator rotor, thus saving several feet in the width of the building.

The administration and amenity block is adjacent to the turbine house, but separate from the main building. An overhead access bridge joins the block to the turbine house. Space heating and hot water are provided by making use of bled steam from any one of the four generator sets, and this arrangement is claimed to be very satisfactory and economic.

Messrs. Rendel, Palmer and Tritton were appointed by the Authority as civil engineering consultants, all mechanical and electrical plant in the station being engineered directly by the Authority.

* See "Some Design Features of the Semi-Outdoor Power Station at Ince," by F. H. S. Brown, *Proc., I.E.E.*, Vol. 101, Part II, No. 80, April, 1954, page 103.

**One of the three side-discharge wagon tipplers at Ince power station. The capacity of each tippler is twenty standard rail wagons (10 to 24½ tons capacity) per hour**

## Boiler Plant

The boiler plant consists of four "Lopulco" radiant-heat boilers with a steam capacity of 550,000 lb per hour at 950 lb per square inch and 925 deg. Fah. at the superheater outlet. The boilers are semi-outdoor. Special precautions have been taken to prevent freezing trouble during winter operation. The drum floor of each boiler is made into a separate enclosure by light sheet cladding, thus giving a measure of insulation from adjacent boilers during maintenance.

The boiler is of three-drum design, each

drum being of forged steel. The furnace chamber is completely water cooled, and the wall tubes are finned. Each boiler is fired by coal which is ground by four suction-type two-roll mills, each of capacity 13 tons per hour. A small "Impax" hammer mill is used for bringing the boiler up to pressure. Four pulverised-fuel burners are arranged at each corner of the combustion chamber for tangential firing. Superheat temperature is controlled by elevating or depressing the angle of the burners. Ignition is by oil burners. The superheater is all-welded, the primary section being composed of multiple-loop horizontal contra-flow elements, while the secondary stage is of the pendant parallel-flow type. Each boiler has an all-welded economiser arranged in two banks. The tube elements are horizontal, and the gases flow in a vertical path between them.

The air heaters consist of mild steel casings, in which are the rotating heating elements. The hot flue gases pass through one side, heating the elements, whilst through the other half passes the incoming air.

The automatic control equipment, operated pneumatically, uses compressed air at a pressure of 30 lb per square inch to govern the fuel, air for combustion, furnace pressure and steam pressure. The main dampers are remotely controlled by hydraulic means from the main panel.

Each boiler is fed by two 100 per cent capacity, electrically driven feed-pumps. The delivery pressure is 1220 lb per square inch when the set is on full load. The pumps are arranged so that in the event of a failure of one pump the standby will start up automatically. The water is first dosed with aluminium sulphate, then passed through pressure vessels containing sand filters, after which it enters the automatic treatment plant. One stream passes through the hydrogen-ion unit, where the salts present in the water are converted to acids. The second stream passes to the sodium zeolite section and undergoes a base exchange reaction. The water delivered from the two processes is then automatically combined so that the bicarbonates in one stream and the acids in the other neutralise, liberating carbon dioxide. The blended water has zero hardness and low alkalinity. The free carbon dioxide is removed from the blended water and the treated water is stored in tanks in the main building, from which it is delivered to the evaporating plant before passing to the boilers as make-up water. The total capacity of the water-softening plant is 270,000 gallons per day.

### Coal, Ash and Oil Handling

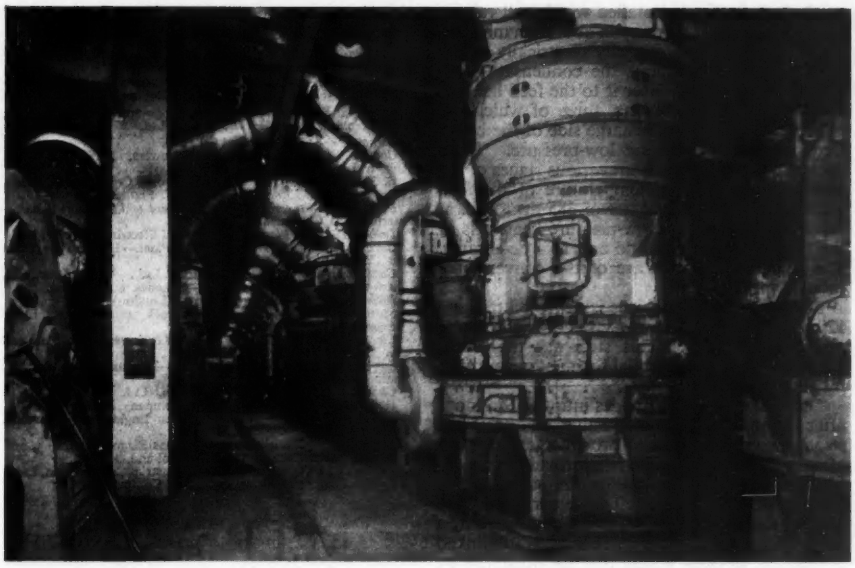
When the station is on full load the consumption of coal can reach approximately 18,000 tons per week. The sidings are capable of accommodating 600 rail wagons (10 to 24½ tons capacity), which are emptied into hoppers by three automatic tipplers. A device used for drawing the wagons on to the tippler platform is known as the "beetle" marshalling gear, and eliminates the use of ropes and capstans. The coal from the tippler hoppers is delivered to feeder belts, which pass the coal to duplicate belts that can deliver 400 tons per hour to the boiler-house bunkers or to the storage area. The coal may be reclaimed from stock by bulldozing it into two underground hoppers whence it is again transferred to the main conveyor system. The conveyor belts are duplicated and each is of 100 per cent capacity. The effective bunker capacity per boiler is 900 tons.

Products of combustion are handled in two ways. Heavy ash falls to the bottom of the combustion chamber and is collected in water-filled hoppers. Light dust goes with the flue gases to a separate collector. The ash hoppers are periodically emptied into a sluiceway in the basement of the boiler-house. High-pressure jets along the whole length eliminate blockage. Ash is removed from the collecting pits by grab and taken to dumping grounds by road. The flue gases pass through mechanical dust collectors (two per boiler), then through two electrostatic precipitators in parallel. Automatic vibrators discharge the latter into hoppers at suitable intervals, and the dust is then conveyed under vacuum to bunkers. A mixer-conveyor takes the wetted dust to the road wagons.

The oil storage installation consists of three 8000-ton tanks. The oil to be used is Bunker C (viscosity at 100°deg. Fah., 4500/6000 seconds Redwood No. 1), and this will be pumped through a single pipeline from the nearby Stanlow oil refinery to storage tanks. The sides and roofs of the storage tanks are lagged, and heating coils maintain approximately 140 deg. Fah. From the storage tanks the oil is pumped through trace heated mains to the auxiliary boiler-house and to the main boilers, and the surplus is circulated back to the tanks. A separate pump house has been provided to house the oil transfer pumps. The auxiliary boiler-house is an addition to the station, and contains three 15,000 lb per hour Economic boilers, which provide low-pressure steam for heating the oil, both in the tanks and pipelines, and before burning in the main boilers. The conversion of the main boilers has been arranged to preserve the unit system originally adopted. Separate oil pumping and heating sets are provided for each of the boilers; these are designed to raise the pressure and temperature of the oil to a maximum of 400 lb per square inch and 300 deg. Fah. to make good atomising possible.

The oil burners are located in the four corners of the furnace in the boxes originally housing the coal burners. There are seven burners in each corner, and the tilting feature for superheat control has been retained.

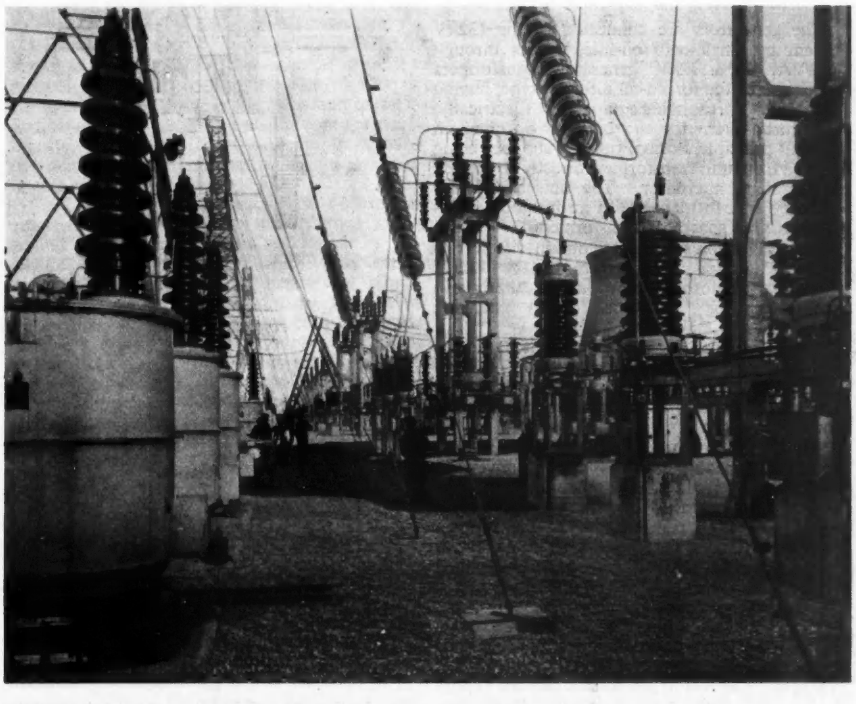
The existing ash hoppers under the boiler furnaces will not be necessary when oil is being burnt, and they are to be isolated. A condensate recovery system is provided.



**The boiler-house mill bay. For moisture content ranging from 3 to 15 per cent in the raw coal, the maximum capacity of each mill ranges from 13 to 11·6 tons per hour. There are four mills per boiler**

### Turbo-Generators and Auxiliary Plant

The four 60,000kW turbo-generators operate under steam conditions of 900 lb per square inch and 900 deg. Fah., running at 3000 r.p.m. Steam from the low-pressure cylinder exhausts into three-pass, twin-casing, surface condensers working under a vacuum of 28·7in of mercury when the machine is operating at 60,000kW. Air is extracted from the condensers by two 100 per cent steam-operated air ejectors, and a



**The 132kV switching station is a double-busbar installation with air-blast circuit breakers and manual isolators**

quick-start ejector is installed which will raise a vacuum of 24in of mercury in about ten minutes.

Two 100 per cent capacity electrically-driven extraction pumps remove the condensate from the condensers and deliver it to the feed heaters. There are five feed heaters, three of which are high-pressure, on the discharge side of the boiler feed pumps, and two are low-pressure. These heaters use steam bled from various stages of the turbine, giving a final temperature of the feed water leaving the last heater of 385 deg. Fah. at full load. One of the low-pressure heaters is of the direct contact type and acts as a de-aerator. The remaining heaters are of the conventional tubular variety.

The steam to the turbines is delivered through 12in diameter pipework which is of a chromium molybdenum alloy. This steel has the creep-resisting properties essential for the temperatures met in this station.

The 12in steam pipe divides into two 9in loops after the main turbine stop valve, delivering the steam through strainers to two emergency valves, after which it splits again to provide steam to four throttle valves admitting the steam to the high-pressure turbine. The emergency and throttle valves on the turbines are controlled by a relay oil pressure system. This system is linked to various devices which trip the machine by releasing the oil pressure under dangerous conditions such as overspeeding, loss of vacuum, low oil level or certain electrical faults. In addition to the tripping mechanism, the turbine is progressively unloaded should vacuum begin to fall. Similarly, the turbine is unloaded if the boiler pressure falls.

Motor-driven barring gear is installed. This also enables quick starting after shut-down. The main turbine oil pump is centrifugal and takes over from the auxiliary pump when a speed of 2600 r.p.m. is reached. The auxiliary pump feeds the bearings and the governor, and starts automatically if main pump pressure falls below a certain value. A d.c. motor drives a stand-by pump to supply the bearings if the auxiliary pump fails. Two 100 per cent capacity oil coolers and a motor-driven centrifugal oil cleaner are installed per set.

Hydrogen for cooling the alternator is itself cooled in tubular heat exchangers supplied by the circulating water system.

Four circulating water pumps, each of capacity 43,600 gallons per minute, are housed in a separate building, each pump providing sufficient water for one machine.

### Electrical Equipment

The generators are connected to the 132kV system by single-core oil-filled cables through 72MVA, 11·8/132kV generator transformers which are of the forced-oil air-blast type, having "on load" tap changing equipment. Electrically, each turbo-alternator and boiler is operated on the unit principle, normal running supplies being derived from unit transformers directly connected to the main alternator. The unit and boiler auxiliary transformers are in an outdoor enclosure with the generator transformers.

General station supplies are obtained from two 7·5MVA station transformers in the 132kV switchgear enclosure. They are naturally oil-cooled, having "on load" tap changing equipment.

The 3·3kV and 415V airbreak switchgear has breaking capacity ratings of 150MVA and 25MVA, respectively. The switch-boards are in the annexe between the boiler-house and turbine house.

The station is connected to the 132kV switchgear enclosure by conduits which convey all main and multicore cables. The majority of the auxiliary cables inside the station are run in bituminised fibre conduit laid in the topping concrete. Cables, in general, are of the paper insulated, non-draining type. Lead-sheathed V.I.R. control cables and mineral insulated copper sheathed cables are also used.

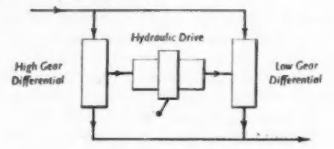
The 132kV substation is a double busbar installation with air-blast switchgear and manually operated isolators. There are nineteen circuit breakers. The 600 lb per square inch air supply is obtained from four automatic three-stage compressors.

### Main Contractors For Ince Power Station

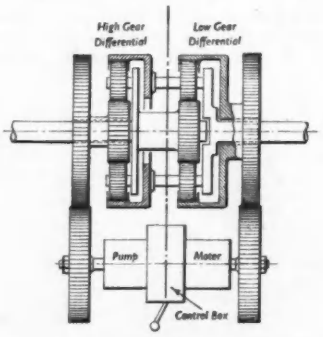
*Reclamation.*—A. Monk and Co.
*Main and Ancillary Foundations, Permanent Roads, Piling, &c.*—Holland & Hannen and Cubitts, Ltd.
*Superstructure, Main Building, Administration and Ancillary Buildings.*—Holland & Hannen and Cubitts, Ltd.
*Structural Steelwork.*—Horseley Bridge and Thomas Piggott, Ltd.; erection, Carter Horseley (Eng.), Ltd.
*Chimneys.*—D. Theaker and Co., Ltd.
*Cooling Towers.*—Film Cooling Towers, 1925, Ltd., J. L. Kier, Ltd.
*Railway Sidings.*—B.C.S. (Engineers and Contractors), Ltd.
*Agricultural and Road Works.*—J. W. Flather, Ltd.
*Boiler Units, Pulverised Fuel Equipment and Auxiliary Plant.*—International Combustion, Ltd.
*Turbo-Alternator Plant.*—The General Electric Company, Ltd.
*Condensing and Feed Heating Plant.*—Hick Hargreaves and Co., Ltd.
*Coal Handling Plant.*—Simon-Carves, Ltd., Naylor Bros., Ltd.
*Ash and Dust Handling Plant.*—Babcock and Wilcox, Ltd.
*Boiler Feed Pumps.*—Sulzer Bros. (London), Ltd.;
*Steam and Feed Pipework.*—Babcock and Wilcox, Ltd.
*Evaporator.*—Aiton and Co., Ltd.
*Circulating Water Pumps, Valves and Pipework.*—Drysdale and Co., Ltd.
*Low-Pressure Pipework and Valves.*—Brightside Foundry and Engineering Company, Ltd.
*Chlorination.*—Wallace and Tiernan, Ltd.
*Water Softening Plant.*—Permutit Company, Ltd.
*Chemical Treatment Plant.*—Paterson Engineering Company, Ltd.
*Tanks.*—Horseley Bridge and Thomas Piggott, Ltd.
*Turbine House Crane.*—Sir Wm. Arrol and Co., Ltd.
*Vacuum Cleaning Plant.*—B.V.C. Industrial Construction, Ltd.
*Station Compressor.*—Ingersoll Rand Company, Ltd.
*Workshop Equipment.*—The Selson Machine Tool Company, Ltd.
*Diesel Shunting Locomotives.*—John Fowler, Ltd.
*Auxiliary Cranes.*—Wharton Crane and Hoist Company, Ltd.
*Auxiliary Pumps.*—Worthington-Simpson, Ltd.
*Level Equipment* (Cooling Towers and Dust Bunkers).—Fielden Electronics, Ltd.
*Main Switchgear.*—English Electric Company, Ltd.
*Auxiliary Switchgear.*—English Electric Company, Ltd.
*Generator Transformers.*—General Electric Company, Ltd.
*Station Transformers.*—English Electric Company, Ltd.
*Auxiliary Transformers.*—Bonar Long and Co., Ltd.
*Cabling.*—British Insulated Callender's Cables, Ltd.
*Batteries and Rectifiers.*—Chloride Batteries, Ltd.
*Lighting and Heating.*—Geo. E. Taylor and Co. (London), Ltd.
*Telephones.*—Standard Telephone Company, Ltd., Communication Systems, Ltd.
*"Mulsifyre" Equipment.*—Mather and Platt, Ltd.
*132kV Substation (Civil).*—A. Monk and Co., Ltd.
*132kV Switchgear.*—English Electric Company, Ltd.
*132kV Cables.*—British Insulated Callender's Cables, Ltd.
*132kV Lines.*—Watsham's, Ltd.
*Lighting and Heating.*—Thomas Wood and Son (Chester), Ltd.
*Dual Firing Modifications to Main Boilers.*—International Combustion, Ltd.
*Transfer Pumps.*—Mirrlees (Engineers), Ltd.
*Pipework Outside Boiler-House.*—Babcock and Wilcox, Ltd.
*Auxiliary Boilers.*—Babcock and Wilcox, Ltd., Edwin Danks and Co. (Oldbury), Ltd.
*Tank and Other Foundations and Auxiliary Boiler-House.*—J. L. Kier and Co., Ltd.
*Structural Steelwork.*—Ed. Wood and Co., Ltd.
*Switchgear.*—Castle Fuse and Engineering Company, Ltd.
*Cabling and Lighting.*—George E. Taylor and Co. (London), Ltd.

# M.I.R.A. Positive Displacement Hydraulic Transmission

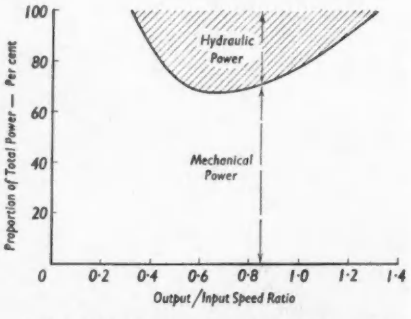
AN interesting exhibit at the 1957 Motor Show is the new hydraulic transmission, developed by the Motor Industry Research Association, of Lindley, near Nuneaton, mainly for use in medium-sized cars. The display shows the new transmission unit, located in the usual way between the engine and the propeller shaft, and demonstrates how by a simple automatic control the transmission ratio can be varied by the accelerator position.




DIAGRAMMATIC ARRANGEMENT.
(a)




TYPICAL PRACTICAL ARRANGEMENT.
(b)




DIVISION OF POWER IN A TYPICAL VERSION OF THE DOUBLE DIFFERENTIAL SCHEME.
(c)

**Fig. 1—Principles of M.I.R.A. positive displacement hydraulic transmission**

The M.I.R.A. torque converter consists of a hydraulic drive arrangement combined with epicyclic gearing in a "differential" or "shunt type" transmission. Transmissions of this kind have been known for some time; they are based on the characteristic ability of an epicyclic gear train to serve—in certain drive conditions—as a differential. This property is utilised to split the input torque between mechanical and hydraulic branches, so that, for the purpose of increasing the overall efficiency of the combination, the amount of power transmitted by hydraulic means is kept at a minimum. All previously known shunt type transmissions, using a hydrodynamic drive in combination with one single differential only, have done so at the cost of a considerable reduction of the maximum obtainable torque ratio. The M.I.R.A. transmission, using two sets of differential gearing in combination with a hydrostatic drive, is designed to obtain a wider range of speed ratios while using the same small amount of hydraulic power.

In the new transmission the hydraulic drive is employed to control the speed and torque on each of the two control members (sun wheel or annulus) associated with two epicyclic gear trains. Members in each gear train are connected to input and output shafts so that the amount of power transmitted by either differential is dependent on the torque applied to the third (or control) member in each gear train. The hydraulic drive is inserted in this system between the two control members so that the torque developed in one of these members can be converted to some other value of torque which is then transferred to the second control member. The arrangement is shown in diagrammatic and practical form in Fig. 1 *a* and *b*; the graph Fig. 1 *c* shows the proportions of total power transmitted by the mechanical and hydraulic units at various speed ratios. As seen in Fig. 2 a hydrostatic variable drive is interposed between the control members of the high gear and the low gear differentials. It consists of a pump and a motor, and is used to regulate the flow of power from input to output in each of the alternative paths which exist in these two gear trains. When the hydraulic motor is at maximum delivery then the low gear differential only is used to transmit power at a low speed and, correspondingly, increased output torque. Conversely, when the hydraulic pump is at maximum fluid delivery the high gear differential transmits power to the output shaft at reduced torque, but at a higher speed, equivalent to an overdrive ratio.

In this hydraulic drive the pump and the motor units are interconnected so that whenever the pump is at maximum delivery, then the motor is at zero delivery. On the other hand, as the control lever is moved towards the other limit, the pump delivery falls progressively to zero, whilst the motor delivery increases from zero to

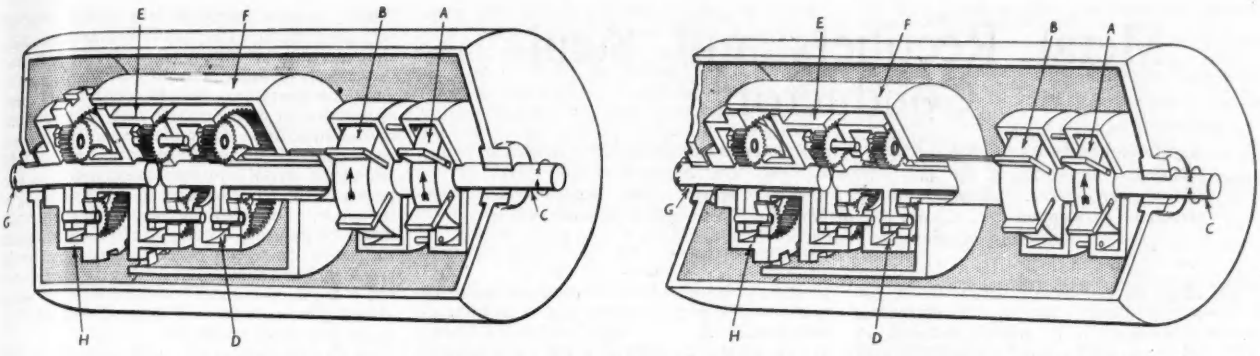



**Fig. 2—(Left) Intermediate gear variable between 3 to 1 reduction and 1 to 1·4 overdrive. (Right) Reverse gear—reduction 4 to 1**

maximum. At each extremity of lever movement, therefore, one hydraulic unit is at zero delivery and the other at maximum delivery. The unit that is adjusted to zero delivery cannot accept any hydraulic fluid ; consequently, the other unit at maximum delivery is unable to rotate except for a slight amount to make up leakage losses. In this condition the unit at maximum delivery and the control member of one epicyclic gear connected to it are locked stationary, with the result that all the power is transferred by this particular gear train and none is transmitted hydraulically. The other hydraulic unit, being at zero delivery, is able to rotate freely, and its control member and the associated gear train do not transmit any torque or power.

This method of locking alternatively the control members of individual epicyclic gear trains by hydraulic means is comparable with the use of friction brakes, commonly used in epicyclic gearboxes to select various fixed gear ratios. The main difference between the latter system and the M.I.R.A. transmission is the fact that, by using hydraulic units to control the members of two epicyclic gear trains, torques can be applied to these members in the rotating as well as in the stationary condition. All intermediate values between the two limit ratios, determined by the layout of the gearing, can be obtained by the variation of the hydraulically transmitted power. This proportion, of course, varies with the range of variable ratios ; various useful combinations, however, can be effected so that not more than from 25 to 35 per cent of the total power is transmitted by the hydraulic drive. In such an arrangement the unavoidable losses incurred in the hydraulic circuit are relatively small compared to the total transmitted power, so that a satisfactory overall efficiency is to be expected. The small effort required to operate the hydraulic control valve makes the M.I.R.A. transmission particularly suitable for automatic operation, which is effected, in the usual way, by the interaction of the accelerator position and of a centrifugal governor driven by the output shaft.

The design of the M.I.R.A. transmission as displayed at the Motor Show differs from the sketch, Fig. 1*b*, and is shown in perspective presentation in Fig. 2. The hydraulic units (here shown as a sliding vane pump *A* and an equivalent motor *B*) are actually of the " slipper " type, and their delivery volume is controlled by varying the eccentricity of the pump housing, or, more accurately, of the slipper track relative to the common axis of the rotors. The interconnected radial displacement of the two slipper tracks is effected by hydraulic servo action under the influence of the torque-regulating control valve. The input shaft *C*, directly coupled to the engine flywheel, is integral with the planet carrier of the first gear train *D*, and with the sunwheel of the second train *E*. The pump rotor is connected through a hollow shaft, concentric to the input shaft, with the sunwheel of the first gear train, and the rotor of the hydraulic motor through a second, also concentric, hollow shaft with the selector drum *F*. The latter is slidably mounted on the splined hollow shaft leading to the hydraulic motor and, in forward drive, is locked by a dog clutch to the annulus of the second gear train.

Referring to our previous description of the general principle it is easy to understand that, with the pump adjusted to maximum delivery and unable to turn, the front sunwheel is locked and the planet carrier, integral with the input shaft, turns the annulus of the first gear train at increased speed, thus transmitting a correspondingly reduced torque via the planet carrier of the second gear train to the output shaft *G*. In this position the hydraulic motor is rotated via the selector drum by the annulus of the second gear train, but, being at zero delivery, it is spinning freely or, in any case, without any appreciable loss. The gear ratio, chosen for a given set of design parameters, constitutes an overdrive ratio of 0·7 : 1, the whole torque being transmitted by mechanical means only.

The other fixed gear ratio, this time the reduction ratio of 3 : 1 is obtained when the rotor of the hydraulic motor (the latter being set to maximum delivery), is held stationary. In this case, the selector drum and the rear annulus connected to it are locked and the rear sunwheel on the input shaft rotates the planet carrier of the second gear train at reduced speed. Whilst this ratio is used the pump rotor, adjusted to zero delivery, is spinning freely.

Between these two fixed conditions any intermediate gear ratio can be selected by setting the control valve so that one part of the torque is transmitted by mechanical means, and the other one through the hydraulic circuit. The efficiency of this latter circuit is not likely to be higher than about 65 per cent, but as—in the most unfavourable circumstances—only about 35 per cent of the torque is transmitted by hydraulic means, the overall efficiency of the transmission should be in the neighbourhood of 85 to 90 per cent.

Reverse gear (at a 4 : 1 reduction) is effected through axially shifting the selector drum by manual means or by remote control out of engagement with the dogs of the second annulus and, through the neutral position (used for starting the engine or for towing the car), into engagement with the annulus of the epicyclic reverse gear *H*.

The M.I.R.A. transmission also offers an automatic clutch operation, not included in the exhibit at the Motor Show, obtained by the use of a variable-pressure relief valve which controls the fluid pressure inside the closed circuit between pump and motor. Release of pressure in this circuit allows both hydraulic units, together with the connected control members of the two epicyclic gear trains, to rotate freely, and no torque can be transmitted through the gearing. Closing the valve gradually restores the fluid pressure in the circuit, thus allowing the transmission to take up the torque as smoothly as a hydraulic coupling.

The M.I.R.A. transmission as displayed at the show is still in an experimental stage, and some details have yet to be finalised. Such questions as the quantity of the fluid in circulation (most probably engine oil), its optimum viscosity, and the advisability of using an oil cooler, are still under consideration. Provided, however, that the new transmission behaves as well in service operation as on the test bed, there is every prospect that it might eventually be adopted by one or the other of the member firms of the Motor Industry Research Association.

## Water Power Proposal in the Canadian North West

EARLIER this year we recorded that a comprehensive survey of the Rocky Mountain Trench area of British Columbia—an area of 50,000 square miles about which little was known —had been initiated by the Wenner-Gren Foundation. A period of two years was envisaged for surveys of hydro-electric power, mining, forestry, communications and transport, but already a major result has been achieved. On October 8, the Prime Minister of British Columbia, Mr. W. A. C. Bennett, announced that an agreement had been signed between his Government and the Wenner-Gren Foundation, authorising the latter body to develop a vast hydro-electric potential in the area.

The project has not yet been designed in detail, and only the overall potentialities have been assessed. In outline, a dam on the Peace River is proposed, somewhere near Finlay Forks, north of Prince George. In this region, the Parsnip and Finlay rivers flow north and south respectively, along the rift valley known as the Rocky Mountain Trench. They join at Finlay Forks, the confluence, known as the Peace River, flowing eastwards out of highlands into Alberta, and thence northwards. If a dam were built as suggested on the Peace River, the reservoir would extend north and south, along the two tributaries in the Rocky Mountain Trench.

As the proposals are defined at present, an increase of level from 1920ft to 2350ft above sea level would be effected at the dam site, giving a reservoir about 130 million acre-feet in capacity, extending for 260 miles along the Trench. The estimated output of the scheme is put at about 3000MW at 100 per cent load factor. The scheme would be larger than any water power scheme at present in operation. The survey for this hydro-electric proposal has been carried out by the British Thomson-Houston Company, Ltd.

One reason why the scheme is considered to be advantageous is that the salmon industry will not be affected, as it would be if alternative, but smaller, proposals on the Columbia or Fraser rivers were proceeded with. It also avoids international problems of " downstream benefit," which have affected other proposals, such as the enormous project envisaged further north, based on Lake Atlin and the Yukon River (see THE ENGINEER, August 20, 1954). The estimated water power resource of British Columbia has been given as 25,500,000 h.p. (without the 4,000,000 of this present proposal), of which 10 per cent has been utilised. Another 12,500,000 h.p. will have to be developed in the next twenty years it is envisaged, and the Peace River proposal is considered to be one of the most favourable schemes on which to start. At present the establishment of power-consuming industry in the area is not contemplated, and the scheme is evidently attractive enough to be considered in conjunction with transmission lines about 500 miles in length to Vancouver, the main centre of population.

In his speech announcing the agreement, Mr. Bennett said that he considered the scheme would solve some of British Columbia's most acute development problems ; it would change the map of British Columbia and might alter the climate of the north lands.

# Metal Rectifiers and Semi-Conductors

*A private exhibition of metal rectifiers and semi-conductors is being held this month at the works of the Westinghouse Brake and Signal Company, Ltd., Chippenham, Wilts. Rectifiers made by the company, using copper-oxide, selenium, germanium and silicon, are displayed in this exhibition, and a brief outline of these developments is given here.*

THE metal rectifier as a practical device for converting direct current to alternating current is based on Dr. Grondahl's discovery, in 1920, that the conductivity of a combination of copper and cuprous oxide is strongly assymmetrical. The combination acts as a good conductor in one direction and is almost non-conducting in the other and is therefore a rectifier. As a result of the interchange of technical information between the Union Switch and Signal Company in the U.S.A. and the Westinghouse Brake and Signal Company in

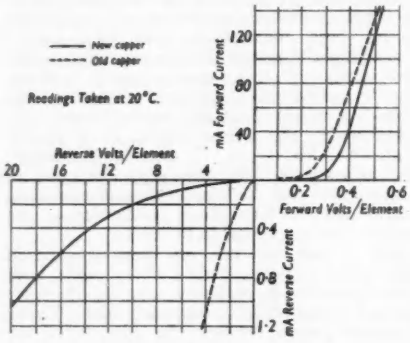



**Fig. 1—Comparison between forward and reverse characteristics of typical copper oxide rectifier and of the improved version**

England, Dr. Grondahl's discovery was developed in both countries and the first metal rectifiers were produced commercially in the middle 1920s. Initially the copper-oxide rectifiers were applied to railway signalling, but other uses were soon found, and by 1930 this method of rectification was common practice in telecommunication engineering, electric trucks, electroplating and motor drives.

Basically the copper-oxide rectifier consists of a stack of washers or discs, with one face of copper and the other of cuprous oxide, the washers or discs being stacked in series on an insulating spindle. By connecting several of these stacks or elements in parallel it was possible to obtain large currents, for example, of the order of millions of amperes for electroplating plants. By connecting many of the elements in series supplies of, say, 500kV were obtainable for radiographic work. One disadvantage of the early copper-oxide rectifier was that an equipment to produce large outputs was inherently bulkier and less efficient than other kinds of converter.

By the late 1930s, however, a new kind of metal rectifier, based on the element selenium, had emerged from its development stage and became established as a converter with many advantages over copper-oxide. The selenium rectifier made by the Westinghouse Brake and Signal Company is known by the trade name, "Westalite." With the selenium rectifier bigger and more efficient installations were commercially practicable. For example, in 1950 a "Westalite" 1·1MW installation was built for the charging of trunk telephone terminal batteries. A 1·7MW installation for the generation of chlorine was completed in 1951 and an 8·5MW plant for operating electro tinning lines was installed earlier in 1957. Throughout this period there has been continuous development of the selenium rectifier. The original selenium rectifier was produced by a single voltage process, which gave an element operating at 17V r.m.s. A notable improvement was the double-voltage process, which enabled the input voltage to be raised to 30V r.m.s., and the size of an installation per kilowatt to be roughly halved. Recently new processes have been evolved for improving the stability of the rectifier, whereby it can be operated at higher temperatures, up to 120 deg. Cent. or can be given a longer and more stable working life under normal operating conditions.

Further improvements, including higher efficiency, may be expected from a new process in which the selenium is volatilised on to the supporting plate. We learn that plant for operating this process is now being installed at the company's Chippenham works.

Progress has also been made in the design of copper-oxide rectifiers; the improved performance is illustrated in the accompanying diagrams (Fig. 1), in which the characteristics of the new and old-style rectifiers are compared. It will be seen that the main advance is in the greatly increased reverse resistance without any sacrifice in the low forward resistance required of a rectifier. Accordingly the rectifier element can be operated at higher voltages with reduced reverse leakage. Greater efficiency and economy of layout can be achieved on 24V or 50V systems; conversely at lower operational voltages, as in instruments circuits, the reduced reverse leakage current of the new rectifiers implies improved accuracy and performance.

More recently two new forms of rectifiers using germanium and silicon have become available commercially. The rectifying properties of semi-conducting germanium were discovered in 1948 at the Bell Telephone Laboratories in the U.S.A. In 1950 the Westinghouse Brake and Signal Company began the production of small point contact diodes. At about that time it was discovered that a *p-n* junction of comparatively large area could be prepared by diffusing indium into mono-crystalline germanium.

Power diodes based on this principle are now being made at Chippenham, and it was announced last week that the Westinghouse International Electric of New York is to work with the Westinghouse Brake and Signal Company, Ltd., on semi-conductor developments.

The manufacturing process begins with the reduction of germanium dioxide to germanium. This metal is then refined to a high degree of purity and at this stage selected and accurately measured impurities are introduced to ensure the material has the precise resistivity and conduction characteristics for efficient rectification. Then a single crystal is grown by reducing the metal to a molten state and inserting a seed crystal which is slowly withdrawn; the rate of withdrawal and the temperature of the molten metal govern the structure and diameter of the complete crystal. This crystal is then cut into thin wafers and the wafers are "diced" into pellets. The rectifying junction is created by fusing a portion of pure indium to one surface of the germanium pellet; it is between these two surfaces that rectification actually occurs. The germanium pellet is then soldered to a steel base; an anode rod and flexible connection is mounted on the indium and this assembly is encased in a hermetically sealed metal housing to protect the junction from atmospheric contamination and to provide means for the fitting of cooling fins. The assembly, consisting of the base, germanium-indium junction, anode rod, flexible connection and housing, constitutes a power diode unit.

A more recent development still is that of preparing a *p-n* junction on semi-conducting silicon to give a rectifier which has characteristics in advance of the older metal rectifiers and, in certain respects at least, of germanium.

The manufacturing process proper begins with the growing of a large single crystal from a "seed" crystal immersed in a molten pool of very pure silicon. The resistivity and conduction characteristics of the finished product depend very closely on accurate control of any impurities and the temperature, speed of rotation and speed of withdrawal of the crystal seed determine the crystal structure. After the crystal quality has been checked silicon pellets are produced by slicing the crystal into thin wafers and then into pellets of the required sizes to suit the rating of the diode. The rectifying junction is then established by diffusing a wafer of aluminium to one surface of the silicon pellet. This silicon pellet is soldered to a substantial copper base, an anode rod is mounted in the aluminium, and the whole assembly is enclosed in a metal casing which is sealed to exclude moisture.

In the production of both germanium and silicon rectifiers stringent precautions are necessary to avoid contamination by impurities even in very minute quantities; the quantities involved are of the order of one part in 100 million. It is essential, therefore, to carry out all the manufacturing process, up to that of hermetic sealing, in dust-free conditions. For example, in the new production line for germanium and silicon rectifiers at Chippenham the critical processes are carried out in two "dust-free" zones, to which there is access through an air lock, with changing rooms for the staff so that, as far as possible, no dust is brought into the working area. The first "dust-free" zone is supplied with filtered air from which dust particles over 5 microns are excluded. A separate and similar air supply serves the other zone, but in this instance particles above 1 micron are filtered out.

## Choice of Rectifiers

A comparison of the characteristics of the four main kinds of rectifier described here provides the main technical basis for the choice of an equipment best suited to any given application.

For a given output a selenium rectifier is smaller than a copper-oxide rectifier, while germanium and silicon rectifiers are even smaller. This result depends partly on the low forward resistance per unit area of the semi-conductors and partly on the high voltages which they can withstand in the reverse direction. The forward resistance of germanium is lower than that of silicon, but silicon will withstand a higher voltage than germanium and can be operated at higher working temperatures.

Typical forward and reverse characteristics of the four kinds of rectifier are reproduced in Figs. 2 and 3. From Fig. 2 it may be deduced

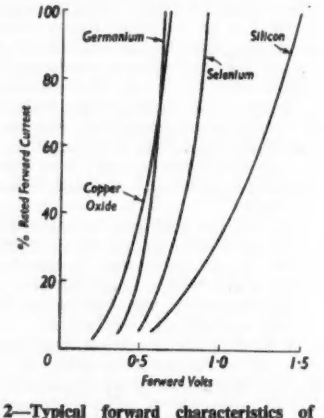



**Fig. 2—Typical forward characteristics of semi-conductor rectifiers**

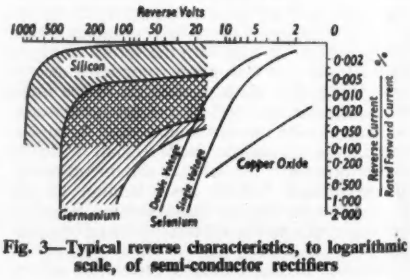



**Fig. 3—Typical reverse characteristics, to logarithmic scale, of semi-conductor rectifiers**

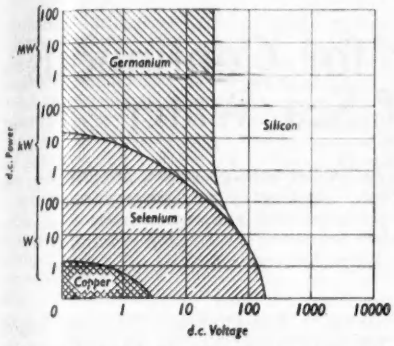



**Fig. 4—First choice of rectifier for any given output and voltage**

that at normal current densities the voltage drop will be low with copper-oxide and germanium, higher with selenium and higher still with silicon. It is unusual for the reverse current to exceed about 0·5 per cent of the forward current and typical values of the operating voltage would, therefore, be copper-oxide 16V, selenium 32V, germanium 70V to 90V, and silicon 100V to 300V. In practice the operating voltage is determined by such factors as the duty cycle, circuit connection and temperature.

Generally the useful areas of application of the four kinds of rectifiers are indicated in Fig. 4, from which the user might make a preliminary choice of rectifier for a given output and voltage. Other important characteristics which influence the choice are summarised below.

*Temperature Characteristics and Life.*—If the temperature of a normally rated copper-oxide rectifier is allowed to exceed 60 deg. Cent., thermal instability occurs, and it causes rapid self-heating and failure of the rectifier.

Normally, thermal instability does not occur in the selenium rectifier and a rapidly destructive condition is not usually reached until the counter-electrode melts at 160 deg. to 170 deg. Cent. Forward ageing, however, increases rapidly with increasing temperatures. Thus, good life can be achieved with normal rectifiers up to 70 deg. Cent. while with special rectifiers it is possible to have a good life up to 130 deg. Cent.

Germanium can operate at a maximum temperature of about 90 deg. Cent. Below 90 deg. Cent. the rectifier appears to be unaffected by the temperature of operation inasmuch as forward ageing and reverse ageing are not apparent. However, on account of the low thermal mass of the rectifier, relatively small overloads can cause rapid increase in temperature and, therefore, it is preferable to limit the total operating temperature to 70 deg. Cent., corresponding to a base temperature of about 50 deg. Cent.

Silicon can be operated at a maximum temperature of the order of 200 deg. Cent. Below 200 deg. Cent. the rectifier appears to be unaffected by the working temperature inasmuch as forward and reverse ageing are not apparent. However, on account of low thermal mass, a factor of safety is allowed and the rectifier is normally operated at 160 deg. to 170 deg. Cent.

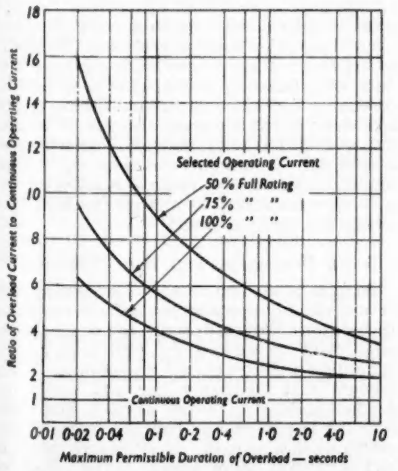



**Fig. 5—Overload characteristics of germanium rectifiers**

*Voltage and Current Overloads.*—Copper-oxide and selenium rectifiers are formed on a substantial metal base and operate at a low current density. They can, therefore, withstand severe current overloads of short duration without damage. Germanium and silicon rectifiers operate at very high current densities and, lacking the thermal mass of the earlier rectifiers, will rapidly overheat if subjected to current overloads (Fig. 5). Voltage overloads will give rise to increased leakage current and self-heating. Again, the silicon and germanium devices are more sensitive and the designer must fully take into consideration the operating conditions when rating the rectifier. In Fig. 6 we show a typical voltage regulation characteristic of a silicon rectifier; variation in output voltages with load current is negligible.

*Parallel and Series Connections.*—With germanium and silicon care has to be taken when connecting in series or parallel. The rectifiers must be selected and closely matched or ratings should be substantially reduced. It is desirable to have individual protection of diodes by fuses or an equivalent. In series connections it may be desirable to employ balance resistances.

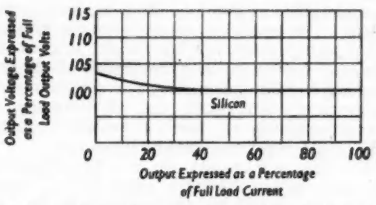



**Fig. 6—Typical voltage regulation characteristic of a silicon rectifier**

*Comparison of Size.*—A germanium rectifier is roughly one-third the volume of a selenium rectifier for the same power output, while silicon will be about one-third the volume of the germanium rectifier or one-tenth of the volume of selenium.

*Efficiency.*—The overall efficiency depends on the transformer and other electrical equipment as well as the rectifier. As a rough guide, the comparative efficiencies of the rectifiers alone are tabulated here.

*Comparison of Efficiency of Rectifiers Alone*

| D.C. voltage | Selenium | Germanium | Silicon |
|---|---|---|---|
| 6 | 85 | 91 | 83 |
| 12 | 91 | 95 | 90 |
| 25 | 91 | 97 | 94 |
| 50 | 91 | 97 | 97 |
| 100 | 92 | 97 | 97 |
| 500 | 92 | 97 | 98 |
| 750 | 92 | 98 | 98 |

At d.c. voltages of up to about 100V, where a single diode in series is adequate, the lower forward resistance of germanium will give it higher efficiency compared with silicon, but at higher voltages, where a greater number of germanium diodes are necessary, the efficiency of germanium and silicon are often comparable and of the order of 97 to 98 per cent, and the tendency is for silicon to be slightly superior.

## Exhibition of Metal and Semi-Conductor Rectifiers

A private exhibition is being held this month in the Westinghouse works at Chippenham to indicate the various fields of application for metal rectifiers and semi-conductor rectifiers and to give some idea of the company's effort in research and development on semi-conductors. A summary of the exhibits is given below.

### Copper-Oxide

Current developments in copper-oxide rectifier units for moving-coil instruments and in telecommunication rectifiers for polarising, metering circuits, &c.

### Selenium

A display of "Westalite" rectifier units ranging from sub-miniature types for electronic circuitry to large power supply units, employing various methods of cooling.

8V, 1500A, "Wesculite" rectifier for electro-deposition (type NWP.8/1500), water cooled.

Power supply unit for spark erosion machine tool (type 1071) in operation.

8+8kW rectifier for compressor and charger supplies on new multiple unit rolling stock of British Railways (type 1285).

Model of tinning line power supply using transductors as means of current regulation (type 5001) in operation.

### Germanium

A display of germanium diodes, "Finnodes" and various cooling assemblies.

10kW transformer and rectifier for 50V and 100V d.c. supplies (type G3T.50/200).

16V, 1000A transformer and rectifier for electro-plating (type GNF.16/1000).

Transformer and rectifier for d.c. supply to organ manuals (type GT.13D5/20).

Transformer and rectifier equipment for float charging 50V telephone exchange batteries of the British Post Office (type 5000).

### Silicon

A display of silicon diodes, "Finnodes" and various cooling assemblies.

460V, 600kW industrial rectifier (type 6001).

240V, 250kW industrial transformer and rectifier with regulated output control in operation (type 6002).

60V, 500A transformer and rectifier for anodising (type SNA.60/500).

8V, 250A rectifier for electro-plating (type SCA.8/250).

Rectifier for constant potential battery charging (type SWM. 1200).

250V, 10kW industrial transformer and rectifier (type S3T. 250/40).

250V, 15kW industrial transformer and rectifier (type S3T. 250/60).

250V, 40kW industrial transformer and rectifier (type S3T. 250/160).

Taper charger for industrial truck batteries (type SVZ.18/50).

Amongst the exhibits which attracted our interest during a recent visit to this exhibition is the selenium rectifier power supply unit for spark erosion machine tools. This equipment is typical of a design produced specifically to a customer's requirement. It provides the necessary controls and d.c. power supplies used for the "Sparcatron" method of machining introduced by Impregnated Diamond Products, Ltd. The equipment can be operated from either a 200/250V or 340/440V, 50/60 c/s, three-phase supply, and has adequate output for supplying up to four workheads. When used in this way, however, three auxiliary control units are necessary. The rectifier circuit feeds a relaxation type capacitance-resistance oscillator and, by the use of control switches and variable resistances, complete control of the whole process of machining can be regulated from the cabinet. Full protection against overload and fault condition is provided, together with the usual metering and control.

Another exhibit, the 16V, 1000A transformer and germanium rectifier for electroplating (type GNF 16/1000) is typical of demands visualised for the electroplating industry where, for many years, the selenium rectifier has been established. As an experimental design this equipment has been built using the main transformer as the basis for the mechanical structure and a relatively light cubicle with a hinged door can be used. Forced air cooling is used to dissipate the rectifier and transformer losses. The fan is mounted at the top and the cooling air is drawn into the cubicle above floor level and discharged at the top. An air pressure switch is included to provide an indication of fan failure. This 16V, 1000A equipment probably represents the upper limit for the size of fan-cooled rectifier which could be used without special ducting for the air. No regulator is included in this equipment since a separate manual or motorised controller would normally be sited separately adjacent to the plating vat. The overall size is 4ft 4in high by 2ft 10in wide by 2ft 4in deep, and the net weight is 11 cwt.

The 60V, 500A transformer and silicon rectifier for anodising mentioned in our list of exhibits is an equipment designed to give a d.c. anodising supply for operation from a 380V, 50 c/s, three-phase industrial a.c. supply under temperate operating conditions. This equipment employing silicon rectifier diodes and transformer with class-B insulation is 2ft 8in wide by 1ft 8in deep by 4ft 4in high, and weights 12 cwt. Full-wave rectification is effected by a hexaphase connected rectifier arrangement with double-star transformer secondary windings and interphase reactor. The high reverse voltage characteristic of the silicon rectifier favours this method of connection and the saving made by using a hexaphase rectifier for this particular output voltage more than compensates in cost for the fact that a slightly larger transformer frame is needed compared with that required to feed a bridge-connected rectifier. Circuit protection is provided by means of high-speed line fuses. A resistance condenser surge suppressor network is connected across the transformer primary winding to minimise transformer pressure rise switching transients. It will be appreciated this

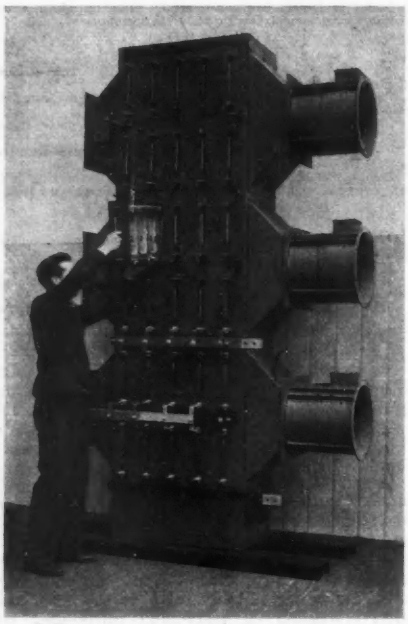


Fig. 7—Experimental 460V, 600kW three-phase full-wave silicon rectifier assembly. The rectifier diodes are rack mounted and cooled by air blast

rectifier application invariably demands d.c. output voltage and current variation necessitating a regulator in the incoming a.c. supply, which may introduce momentary interruptions in the a.c. line voltage, causing transients in the voltage to the rectifier, but for the surge suppressor.

Another exhibit, the 460V, 600kW industrial silicon (type 6001), is an experimental three-phase, full-wave silicon rectifier assembly for use with separate feed transformer and control gear as necessary, to suit applications where a medium voltage two or three-wire industrial d.c. power requirement exists.

The rectifier diodes are rack mounted (Figs. 7 and 8), a form of construction which gives easy access for assembly and maintenance, and can be built up into assemblies of various outputs or shapes to suit individual requirements. Forced-air cooling is provided by three built-in Woods "Aerofoil" fans.

In the racks shown a fuse position is assocated with each diode, but in cases where several diodes are connected in series and each diode does not need an individual fuse an alternative arrangement is available. The equipment measures 5ft 6in wide by 2ft deep by 9ft 6in high, and it weights 10 cwt.

Fig. 8—Rack mounted silicon rectifier diodes, fused and arranged for forced air cooling in the experimental three-phase full-wave 460V, 600kW equipment illustrated in Fig. 7

# Flash Evaporator for Continuous Distillation of Sea Water

*A new design of flash evaporator intended for uninterrupted operation, producing distilled water from sea water, is described here. The whole of the flash evaporator equipment can be accommodated in a single vessel, with a saving in space and external pipework. An operating procedure has been developed for washing deposits from the tube surfaces without taking the evaporator out of service.*

IN a fresh approach to the design of evaporators for producing distilled water in quantity from sea water, Richardsons, Westgarth and Co., Ltd., Wallsend-on-Tyne, has aimed at economising in the size, cost and maintenance of the plant. Irrespective of its output, the new flash evaporator produced by this company can be arranged in a single vessel, with a considerable saving in space and external pipework. Operating methods have been developed by the manufacturer to ensure that deposits are negligible, and that they accrue in the form of a thin layer of soft powder considerably less than one thousandth of an inch thick. The small loss of performance resulting from such deposits can be avoided, since means are provided for washing the deposit off the tube surfaces without interrupting the operation of the evaporator. The plant can, if necessary, be made completely automatic and requires practically no attention and little maintenance.

The new evaporators can now be offered for any duty within the range given below. These figures are based on sea water feed, but the evaporator is stated to be equally suitable for distilling softened water and, with this, higher maximum operating temperatures can be used with consequent higher outputs from a given size of evaporator and, of course, reduced costs. The performance figures given by the manufacturer are based on long periods of operation and research work on a large test rig using sea water as raw feed.

*Range of Capacities of Flash Evaporator.*—Net gained output of distilled water, 10,000 lb per hour to 500,000 lb per hour ; net gained output ratio, 2 : 1 to 7 : 1 (pounds of distillate per pound of steam) ; heat supply, usually low-grade sub-atmospheric steam at 11 lb per square inch absolute minimum pressure.

## Basis of Design

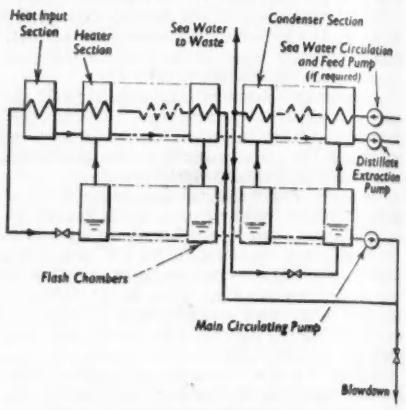
It is possible to design the evaporator unit for a net gained output ratio of less than 2 : 1, but with the new design this ratio would seldom be economically justifiable, the difference in cost and size between a net gained output ratio of 1 : 1 and 2 : 1 being negligible. Nor would there be any saving in offering distillate purities worse than 50 p.p.m. total dissolved solids, although they would be quite acceptable in the case of most drinking water supplies. The choice of the most advantageous net gained output ratio, and the number of units to be used for a particular installation, depends very much on local conditions, and the design of the evaporator has been developed to give maximum flexibility in this choice, using the same basic design.

The method of operation is indicated schematically on the accompanying diagram, which shows that brine is circulated by a pump through a series of heat transfer surfaces, where it is gradually heated by condensing vapour, produced in a series of associated flash chambers. The final heating is normally achieved by an external heating steam supply in the heat input section. The heated boiling brine is then cascaded through the flash chambers which operate at progressively lower pressures and saturation temperatures. In the process some steam is flashed off in each chamber and it condenses (as distillate) on the heat transfer surface associated with each chamber.

Heat rejection from the system is normally effected by a separate cooling water supply to the heat transfer surfaces operating at the lowest temperature and pressure. Most of the cooling water used there is ultimately rejected, but part of it (normally of the order of 200 to 220 per cent of the distillate made) is discharged as feed into the l.p. flash chamber. The excess brine is continually discharged from the system through the blow-down valve. If the feed is 200 per cent of the distillate production then the blow-down will be 100 per cent of the distillate made, and the brine circulating in the evaporator will be concentrated to double the normal concentration of sea water, which is the normal design figure for the plant, except when very high distillate purities are required.

The distillate made in each heater is cascaded from stage to stage and is extracted from the last stage by the distillate extraction pump. The condensate produced in the heat input section is normally also cascaded through the heaters and is extracted from the plant with the distillate.

If an adequate sea water supply under pressure is available, only the brine circulating and distillate extraction pumps shown on the diagram are required for the operation of the plant. An ejector or a vacuum pump is required to maintain the requisite vacuum.




Typical flow diagram of flash evaporator

Generally the heat transfer surfaces of the plant are straight aluminium brass tubes, attached to rolled naval brass tube plates. Where the sea water supply contains sand or other erosive material, the use of cupro-nickel tubes may have to be considered. The heaters and flash chambers of the plant are arranged inside a fabricated mild steel vessel and the arrangement is such that apart from the heat transfer surfaces the vessel does not contain any internal piping or ducting of any sort. Normally the whole plant is arranged inside one vessel and does not require any additional external heaters, coolers or flash chambers, except for the ejector condenser, which is usually separate. Whatever the net gained output ratio, more than one vessel is used only if transport and erection, or other similar considerations, make it necessary ; but it is often convenient to arrange the heat input section in a separate vessel.

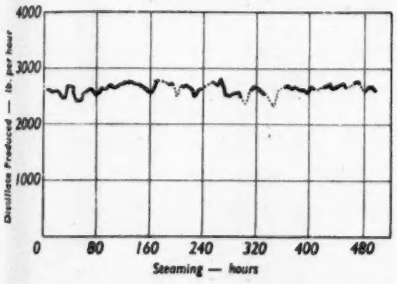
## Scale Formation and Feed Treatment

Because of the importance of preventing scale in continuously operated sea water evaporators, Richardsons, Westgarth built a full-size industrial pilot plant to explore the heat transfer and deposition problems in flash evaporators. It was thought that laboratory size rigs would not produce sufficiently reliable answers, and therefore the test plant was built as large as permitted by existing works facilities such as steam and circulating water supply. The object of the development was to produce design and operational methods allowing the evaporator to

maintain, during thousands of hours of continuous operation, the output and the specific steam consumption measured on a clean unit, and the design is based on the results obtained.

All the development work was carried out by treating the sea water feed into the plant with 5 p.p.m. of "Hagevap LP," sold in Britain by Albright and Wilson, Ltd. The compound is a powder which dissolves readily in water, and it is fed into the pump suction through a needle valve and a rotameter, where the flow is proportioned to the feed flow. The running cost of the treatment is of the order of a halfpenny per ton of distillate produced. The powder is a mild corrosion inhibitor, and the circulating brine, after treatment, is still strongly alkaline.

It was found that, without completely suppressing the formation of deposits, the treatment was successful in every operation provided that the brine was not heated in the evaporator above the figure specified for normal operation, namely 180 deg. to 185 deg. Fah. (84 deg. Cent. approximately). The treatment was proved in over 1500 hours' test rig operation, when various aspects of the deposition problem were studied. As an illustration of the results achieved the graph below summarises a 500 hours' run with a constant steam supply, and constant brine circulation, with a maximum brine temperature of 185 deg. to 190 deg. Fah. (87 deg. Cent. approximately), i.e. 5 deg. Fah. (3 deg. Cent.) higher than specified above. The disturbances shown in the graph are due to the activities of other works




Steam supply and brine circulation rate constant.
Dosing with "Hagevap L.P." 5 p.p.m. on feed quantity, 100 per cent blowdown.
Test commenced September 10, 1956; test ended October 1, 1956.
Disturbances due to works plant marked thus .....
Distillate quantity shown as average over eight hours, plotted every four hours.

**Endurance run on evaporator test rig at 185-190 deg. Fah. top brine temperature**

departments using the same steam and vacuum services as the pilot plant.

The maximum temperature limit stipulated above does not imply a sharp deterioration if it is exceeded. The evaporator was run for several hundred hours at brine temperatures of 195 deg. to 200 deg. Fah. (92 deg. Cent. approximately) with slight deterioration setting in only after more than 100 hours, and then only in the heat input section. Even at brine temperatures of 210 deg. to 215 deg. Fah. (100 deg. Cent. approximately), it took twenty to thirty hours' running to detect deterioration in the heat input section, and on another occasion a sixty hours' run did not produce any measurable change in performance. Therefore, the performance of the plant is not sensitive to occasional excessive brine temperature. It is stated that the evaporator can be run at 10 to 15 per cent overload, which is obtained at top brine temperatures of the order of 195 deg. Fah. (90 deg. Cent.). The only penalty for such operation will be an increased frequency of the washing operations described below.

### Continuous Operation

The slight deposits produced in the tubes after prolonged running using "Hagevap LP" treatment and with low-temperature operation, are a thin layer (a fraction of 1/1000in) of a soft sludge, as opposed to the relatively thick hard scale produced by untreated sea water at high temperatures. These deposits can be brushed off with ease, but it was found that even that was not necessary and methods have been developed for washing them off (taking advantage of the forced brine circulation used in the unit) while the evaporator is in service, without interrupting operation. There is no need to stop any of the pumps or to break the vacuum to carry out the washing procedures, and the plant can be kept in service throughout the operation.

It will be appreciated that the above procedure deals with the problems of scale deposition due to heating the brine in the evaporator. It is assumed that the sea water supplied to the plant will be reasonably clean and free from organic matter, marine life, algæ, sewage, and abrasive matter which may cause fouling or erosion as in a conventional condenser.

### Moisture Separation

A separate large size test rig was built to develop suitable designs and methods of efficient moisture separation in a mock-up of a series of full-size flash chambers. A simple and effective moisture separator has been developed, which is particularly suitable for the flash chamber design used, and is designed to ensure consistent distillate purities ranging between 10 p.p.m. and 50 p.p.m., depending on detail design, vapour velocity, pressure drop permitted, &c. Generally, as would be expected, the better purity figures are achieved at the expense of lower plant loadings, increase in plant size and increased cost of separator. The separators are manufactured from copper sheet as individual units. To avoid the use of bolts and joints inside the flash chambers, they are mounted on simply arranged water seals, so that removal for inspection is extremely easy.

### High-Purity Distillate

The system described above is adequate for normal drinking water supplies and feed water supplies to low-pressure boilers. Where the bulk of the output is needed for feeding high-pressure boilers, a slightly more expensive separator has been developed to yield very much better distillate purities.

Where the heating steam is provided from high-pressure boilers, a separate condensate extraction pump can be arranged to extract the pure condensate from the heat input section without mixing it with the bulk of the drinking quality distillate produced. Arrangements can also be made for a proportion of the distillate stream to be produced to very much higher purity requirements than the bulk of the output, and to be extracted, as boiler feed make-up, together with the heating steam condensate.

### Automatic Control

The operation and control of the unit are stated to be simple. Once vacuum has been raised and the plant has started production, the operator has only to set the distillate production rate by adjusting the brine circulation, the heating steam and feed flows and the "Hagevap LP" dosing flow in that order. The blow-down is automatically controlled. The plant can be arranged for semi-automatic or fully automatic operation, so that it can be run without attendance.

### Heat Supply

The evaporator is designed for heating with any low-grade steam supply available, 11 lb per square inch absolute being the lowest economical steam supply pressure. A small quantity of steam at a higher pressure is generally required for operating the air ejectors, although other methods of venting the plant are available.

In many installations, particularly for large outputs of distilled water, it is expedient to combine power generation with the production of water, by the use of a medium or high-pressure boiler installation, combined with back-pressure or pass-out turbines feeding the evaporator. In other cases heat may be available in streams of hot exhaust gases, e.g. from a gas turbine installation or from refinery operations, and in these cases special arrangements can be engineered for utilising such waste heat in the evaporator system. Such arrangements, it is claimed, will often be cheaper than a conventional waste heat boiler installation.

## Universal Excavator with Pneumatic Control

A PROTOTYPE of the new 30R.B. excavator of Ruston Bucyrus, Ltd., Lincoln, was shown at the Public Works Exhibition in November last year, and we are informed that the firm has placed the machine in the field, following prolonged tests to ensure its efficient performance. This machine, has a capacity of 1 cubic yard with shovel equipment and all its main functions are actuated through pneumatic controls. It is equipped for use as a dragline, shovel, drag-shovel, grabbing crane and crane.

The rigid welded crawler frame of the machine is available in two models, the standard frame being fitted with 30in wide track links giving a total bearing area of about 56·8 square feet. A long, wide spread frame can be supplied with 30in wide track links, giving a bearing area of about 65 square feet, or with 36in wide links giving a total bearing area of 78 square feet. The superstructure revolves on conical hook rollers, two equalised pairs of which are fitted at the

**Cab of universal excavator with pneumatic controls**

front and two single units on the rear. An internal-tooth swing rack is at the same level as the rollers, and there is an air controlled brake on the top of the vertical swing motion shaft. The machinery is mounted on a one-piece cast steel revolving frame and is carried on tandem drum-shafts. Power is supplied by a five-cylinder Ruston oil engine developing 96·8 h.p. at 1200 r.p.m. This engine is mounted at the rear of the frame and power is transmitted to the main machinery through a multi-strand roller chain.

Graduated valves are fitted to the drumshaft clutches to give the necessary "feel" during operation of the machine. When arranged as a shovel the machine has a working weight of just under 30 tons and it is fitted with a 20ft boom with a 17ft handle having an effective length of 16ft. When this boom is at its maximum angle of 60 deg. the maximum dumping height is 22ft at up to 21ft radius and the cutting height is up to 30ft 6in with a 29ft 6in maximum radius.

As a dragline or grabbing crane, the machine has a working weight of just over 29 tons and its lattice construction boom can be extended from 40ft to a length of 60ft by insertion of an intermediate section to give an operating radius from 25ft to 55ft. For lifting crane service the 40ft lattice boom can be extended by intermediate sections up to a maximum length of 100ft, giving a lifting range from 36,950 lb at 12ft radius to 800 lb at 90ft radius, with the long, wide spread crawler frame; and from 33,750 lb at 12ft to 1100 lb at 80ft with the standard frame. As a drag-shovel the machine has a 24ft boom having an 11ft handle which can be fitted with hoe-type dippers of ¾, 1 and 1¼ cubic yards.

Operating floor of signal box at St. Pancras, showing (right) the operating console with its 205 route-setting switches and (left) the train recorder's telephone concentrator

## Signalling Installation at St. Pancras

THE second and final stage in a signalling modernisation scheme at St. Pancras was completed on October 6 when a new power-operated signal box was placed in service. Under the first stage of the scheme colour light signalling and power-operated points were installed on the approaches to the station from Carlton Road Junction some 2 miles out. This stage has been in service since last October and the second stage just completed covers the station and adjoining area. About 253 passenger and 72 freight trains are dealt with daily at this terminus, and the new signal box replaces three mechanical boxes.

The interior of the operating room of the new box can be seen in the illustration on this page; from it there are controlled twenty-three colour light signals, forty-three position light signals, thirty-six route indicators, fourteen being multi-lamp and twenty-two of the stencil type. The operating console has mounted on it 205 route switches (one switch per route), and thirty-three point switches (for individual operation in emergency), together with signal and point indication lights, train describers and other ancillary equipment. Behind the console is an illuminated track diagram covering the whole area controlled from the box. It is divided into sixty-four track circuit sections, the occupation of each by a train or engine being indicated separately by two red lamps.

Block working on the up and down fast lines between St. Pancras and Dock Junction box has been abolished and in its place train describers are to be provided in each box.

The resignalling scheme has involved the installation of sixty-one pairs of electro-pneumatically operated points. To facilitate the changeover from the former mechanical points to the new method of operation, and to reduce the amount of work to be done on the opening day, the points in the station area were converted and have been worked temporarily by the new electro-pneumatic mechanisms from the old station signal box.

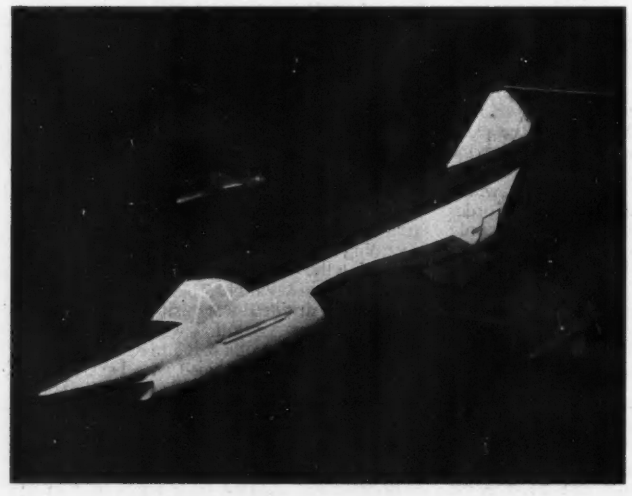
Adjacent to the new signal box building there are a power house, a workshop and a compound enclosing cooling tanks and air reservoirs. A relay room, which occupies the whole of the middle floor of the signal box, houses some 1400 plug-in relays. The power house contains the main supply and distribution switchboards and a standby diesel-driven alternator set capable of taking over the full load automatically in the event of the failure of the normal power supply. There are also two motor-driven compressors supplying air for point operation and one standby diesel compressor which cuts in automatically should the electric supply fail or the pressure in the high-pressure reservoir drop more than 25 per cent.

The normal 415V, three-phase, 50-cycle supply for the whole signalling load and compressor motors is taken from the British Railways Stonebridge Park power station. One phase is transformed to 650V and distributed to the more remote locations over a 650V ring main. Locations in the station area are fed from a 110V ring.

The main contractor for this signalling installation was the Westinghouse Brake and Signal Company, Ltd., and the train describer equipment was supplied and installed by Standard Telephones and Cables, Ltd.

## Supersonic Naval Interceptor

LAST week, Saunders-Roe, Ltd., disclosed that it had designed a high-altitude, supersonic, mixed-power, naval, all-weather, interceptor aircraft, to satisfy the requirements of the British Naval Staff, and that a number of prototype aircraft are being built under contract from the Ministry of Supply. The aircraft, which is designated "S-R 177," and of which we reproduce the photograph of a model, is directly developed from the "S-R 53," mixed unit interceptor, which made its first flight in May, 1957, and was demonstrated at Farnborough in September last and was described in the May 24 issue of THE ENGINEER. Power for this high-performance naval fighter is provided by a "Gyron Junior" supersonic turbo-jet and a fully controllable "Spectre" rocket engine, both being products of the de Havilland Engine Company, Ltd. A mixed power formula in an aircraft of very advanced design has long been advocated by the two companies concerned, and in this aircraft the jet power is used for cruising at subsonic speeds, while the fully controllable rocket motor is available to give rapid acceleration to speeds in excess of Mach 2. This use of the jet engine for cruising purposes ensures that the aircraft has a range and endurance equal to or better than existing types, while the acceleration imparted by the rocket motor makes for quicker and more certain interception. Compared with the "S-R 53" the "S-R 177" has greater weight and slightly greater linear dimensions and there is a difference in the radar equipment, air interception radar being fitted. The armament consists of "Firestreak" infra-red homing guided weapons. The landing weight is low, so that the aircraft can operate from short runways and tactical air strips and is capable of landing on aircraft carriers. Fundamentally the aircraft has been designed to bridge the gap between the use of manned aircraft and the operation of a defence system based upon surface launched and anti-aircraft missiles.



Model of the Saunders-Roe "S-R 177": notice the retractable probe for refuelling from a drogue

## Multi-Point Lubricator

AN improved model of the hand-operated "Multiminor" lubricator made by Centralube, Ltd., Great Western Trading Estate, Park Royal Road, London, N.W.10, is illustrated above. This lubricator is designed to supply 0·4 gramme of grease or oil to up to eight points on each single downward movement of its lever. Its container holds 9 oz. of grease or ¼ pint of oil and is fitted with a screw which can be used to deaerate grease and avoid chance of air locks.

Hand-operated lubricator with eight feed line outlets and delivering 0·4 gramme of grease to each line on every downward stroke of the hand lever

The greasing line feed outlets are arranged at different levels round the lubricator and the internal piston which feeds the grease into the lines feeds each point in succession. Lubricant cannot be fed to any one outlet until discharge to the previous point has taken place. The makers say that the design is such that it does not matter whether one bearing to be lubricated is loose and another tight as all will receive the same amount.

# Industrial and Labour Notes

### Overseas Trade

The provisional figures for the United Kingdom's overseas trade in September show the value of exports as £246,300,000, which was £23,000,000 lower than in August. It must not be overlooked, of course, that the effect of annual holidays is normally seen most clearly in the September trade figures. The Board of Trade says that in the first nine months of this year exports were 7 per cent higher than in the comparable period of 1956. September imports, valued at £308,400,000, were also lower, though in the first nine months of the year they were 6½ per cent higher than in the corresponding period of 1956. The value of re-exports in September was £9,800,000, so that the visible trade deficit for the month was £52,300,000, which was £3,500,000 less than in August. In the first nine months of the year the deficit averaged £57,000,000 a month, or £4,500,000 higher than in the comparable period of last year.

The Board of Trade has stated that in September exports from the United Kingdom to North America were valued at £32,300,000. Exports to the U.S.A. over the first nine months of this year were 10½ per cent higher than a year earlier, and those to Canada were 12 per cent higher.

### Iron and Steel

Britain's iron and steel production recovered during September from the influence of annual holidays. The output of steel ingots and castings averaged 438,200 tons a week, compared with 417,000 tons a week in September last year. In the first nine months of this year steel production totalled 16,202,000 tons, an increase of 6 per cent compared with the figure for the corresponding period of 1956. Pig iron production in September averaged 282,700 tons a week, compared with 252,500 tons a year earlier. The Iron and Steel Board has estimated that for 1957 as a whole pig iron output will be about 14,500,000 tons, or 1,300,000 tons above the 1956 total. This increase is being achieved without any addition to the average number of furnaces in blast; there are ninety-eight furnaces operating this year, compared with 100 in 1956. The higher output is being obtained by large new furnaces coming into use in place of old plant.

About raw materials, the Iron and Steel Board says that receipts of home-bought scrap at steel works and foundries averaged 102,000 tons a week in the first nine months of this year, compared with 94,800 tons in the corresponding months of last year. Total receipts this year may reach about 5,250,000 tons, or 400,000 to 500,000 tons more than in 1956. The increase, it is stated, is accounted for largely by Government surplus disposals consequent upon the revision of the defence programme. The Board goes on to say that, whilst home supplies of both pig iron and steel making scrap have increased substantially, the requirements of pig iron for the production of castings have been reduced. During the first half of the year, the output of iron castings was about 7 per cent less than in the first half of 1956. The total supply of pig iron and scrap from home sources for steel making (including pig iron obtained from furnaces normally producing foundry iron) has been 11 per cent greater than last year. This has resulted in a reduction of imports of pig iron and scrap and in a building up of stocks. Pig iron and scrap imports this year should amount to only 1,000,000 tons, or 500,000 tons less than last year. Next year, scrap and pig iron imports are expected to fall to below 500,000 tons, those of pig iron being limited to small balances of outstanding contracts. Supplies of imported iron ore are satisfactory, and during the third quarter a record quantity of over 5,000,000 tons was brought in. At the end of September stocks of imported ore and of pig iron and scrap were all substantially higher than at the corresponding date last year.

### Steel and the Free Trade Area

The British Iron and Steel Federation has included in the latest issue of its bulletin *Steel Review* an assessment of the advantages and disadvantages of association with a unified European market. It starts off by recalling that a year ago the steel industry expressed conditional support for plans for a European Free Trade Area, and says that subsequent developments have been followed closely. The direct stake of the steel industry in such a Western European market is limited, as direct steel exports to O.E.E.C. members account for only 3½ per cent of Britain's total steel output. It is, therefore, concern for the position of its main customers the British steel-using industries, which is the major factor determining the steel industry's attitude. The West European market already accounts for a quarter of the exports of the steel-using industries and, the *Review* comments, its importance may be expected to increase. If British steel-using exports to the area were put seriously in hazard, as they would be if Britain remained aloof from any new unified market, there might be a serious check to the growth of steel demand.

But, the *Review* continues, association with Europe would bring disadvantages as well as gains. British industry may have to face two major adjustments, the one an adjustment to the loss of tariff and quota protection in the home market, and the other an adjustment to the loss of raw material cost advantages. Since the war, British home trade prices of coal, scrap and steel have been below the prices ruling in world markets. In part, this has reflected certain real cost advantages, such as those springing from the heavy investment in steel plant and the efficiency of British scrap collection arrangements. In part also, it has reflected the price policies pursued by successive British governments. As a result, the *Review* explains, the British steel industry has had access to its basic raw materials on advantageous terms and so has had a cost advantage as against foreign competitors in world export markets.

British steel prices, however, are now no longer the lowest. It remains to be seen, the *Review* observes, whether this limited loss of price leadership will continue or whether the upward movement of costs which led to the British price increases will also be reflected in German and other price increases before the end of this year. Even if they do, the *Review* suggests, entry into the Free Trade Area would involve changes which would be likely to cut deeply into the price advantage on coal, scrap and steel. The policy of maintaining low home trade prices for these products has hitherto been successful because it has been open to the Government to check the natural tendency for these goods to flow out to foreign markets offering higher prices by reliance on export restrictions. A Free Trade Area Convention, the *Review* says, would be likely to require the abolition of all state export restrictions within the first transitional phase of four to six years and to impose some degree of restriction on other measures having an equivalent effect. In face of such rules, it is asserted, the maintenance of artificially low prices in one national sector of an open European market would become impracticable. Higher prices would be the only way left to keep adequate supplies at home once export restrictions disappeared. In the case of steel, it is thought that prices would be likely to be forced up, not only because of the pressure of demand following the ending of export restrictions, but also because of the upward movement of costs. Some increase in British domestic steel prices, it is believed, would be an inevitable consequence of entry into the Free Trade Area.

### Chamber of Shipping

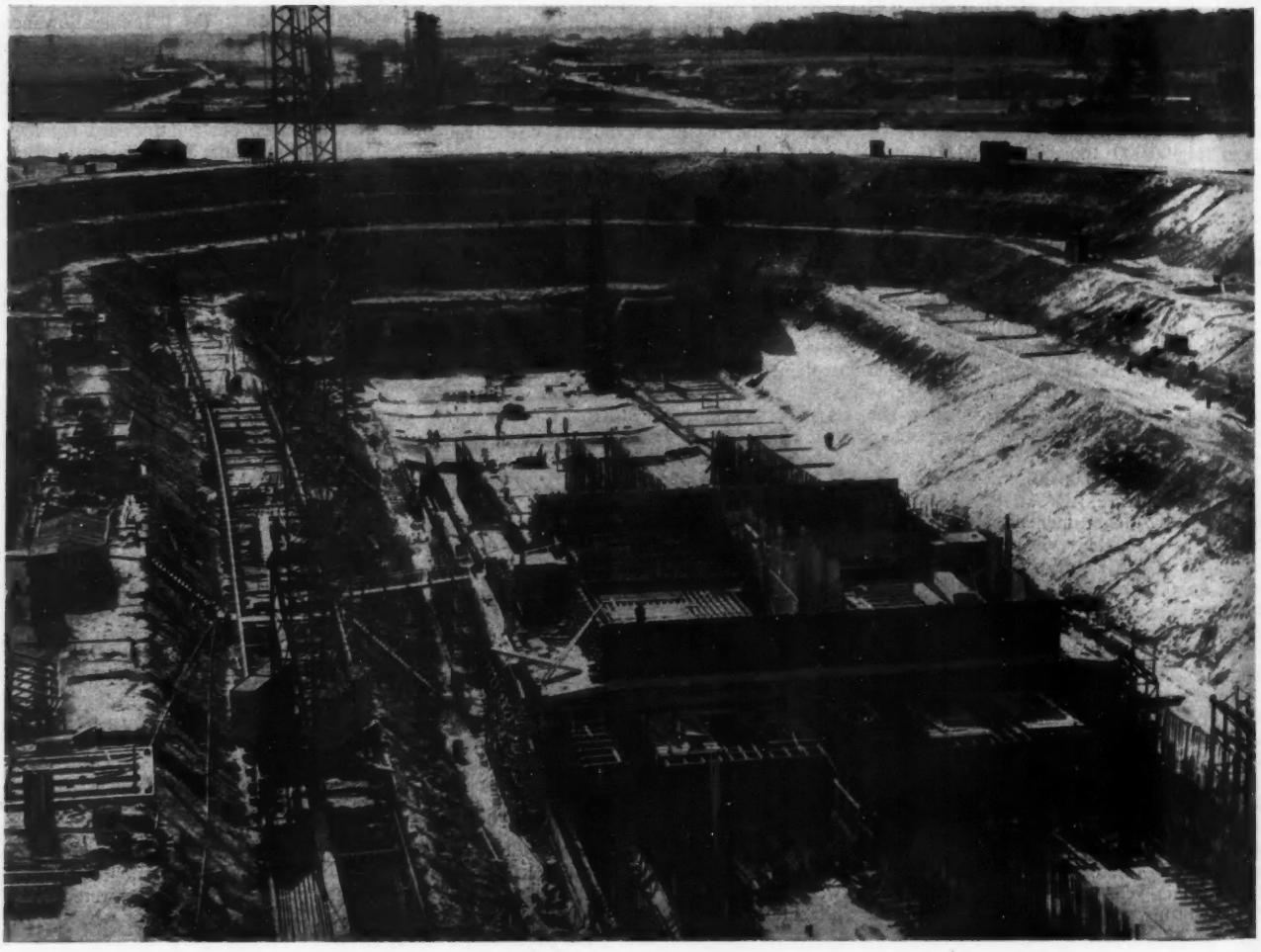
At the annual dinner of the Chamber of Shipping of the United Kingdom, which was held on October 7, the president, Viscount Simon, said that shipowners, as servants of international trade, must provide the necessary services at a competitive price without the benefit of any protection against world competition. This price, he continued, not only had to meet running expenses and provide interest on the capital invested, but also had to cover fleet replacement, an essential item since the fleet must be kept up to date with new and more economic ships. In a period of inflation, replacement of ships was a problem of increasing difficulty, the solving of which had been helped by the 40 per cent investment allowance, a measure which, he emphasised, was essential for the survival of British shipping and the continuance of its contribution to Britain's economy. The president went on to say that the allowance did not put British shipowners on a par with those who evaded paying taxes by trading under a "flag of convenience." He did not advocate that British shipowners should adopt such flags, but put forward the idea that genuine maritime nations should form a closed market for new and second-hand ships and so deny ships to those operating under a "flag of convenience," with the eventual result that such fleets would disappear. Lord Simon mentioned various objections to the scheme, but said he thought that the results would justify the immediate sacrifices entailed.

### Employment and Unemployment

At the end of August, the total working population numbered 24,057,000, of whom 23,111,000 (15,302,000 men and 7,809,000 women) were in civil employment. The Ministry of Labour's analysis of these figures shows that 9,186,000 people were engaged in the manufacturing industries during August, an increase of 47,000 over the preceding month. For the first time for several months there was a sizeable increase (20,000) in the number employed in the engineering, metal goods and precision instruments group, the total at the end of August being 2,793,000. The number of people engaged in the vehicle building industry also increased in August by 9000 to a total of 1,211,000.

About unemployment, the Ministry of Labour states that on September 16 there were 267,406 people registered as out of work, compared with 265,627 a month earlier. The September figure included 108,233 who had been unemployed for more than eight weeks and 7139 who were temporarily stopped.

# THE VELSEN TUNNEL, HOLLAND



# Completion of the Velsen Tunnel

THE Velsen tunnel, which passes under the North Sea Canal close to Ijmuiden, on the Dutch coast, has now been completed, and was inaugurated by H.M. Queen Juliana of the Netherlands on September 28. The tunnel consists of dual carriageways for motor vehicles and a double-line railway track ; the railway tunnel is about 2000m in length, with a further 1200m of approaches, and the road tunnel is about 750m long, with about a further 900m of approaches. Traffic estimated for the road tunnel is 35,000 vehicles per day in each direction ; the upper illustration on the opposite page gives an idea of the traffic on Sunday, September 29, the day after the opening.

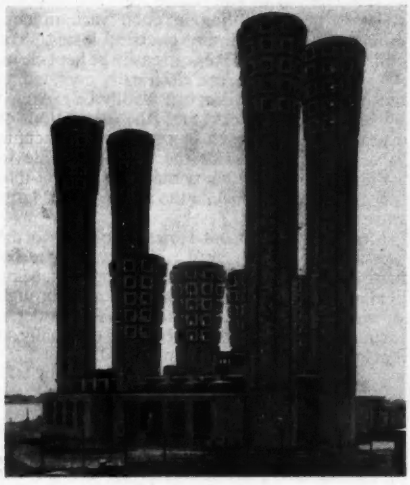
Velsen tunnel is noteworthy as a civil engineering work, not only on account of its size, but because of the methods of construction. A cut-and-cover technique was used, and the separate road and railway "tubes" were built in reinforced concrete in a deep excavation, which extended to 28m below the general surface level. The lower illustration opposite shows this work in progress ; everywhere order is apparent and construction of the tunnel appears to be straightforward and simple. The skill in planning and execution, which have given this false impression, have been such as to make the Velsen tunnel project a model of its kind.

A detailed account of the problems of ground water lowering—in two stages to present brackish and fresh ground water respectively above and below a clay stratum across the site—and of planning progress to phase with a canal widening, was given in the supplement published with THE ENGINEER of June 11, 1954. Here, only one or two salient points are recalled.

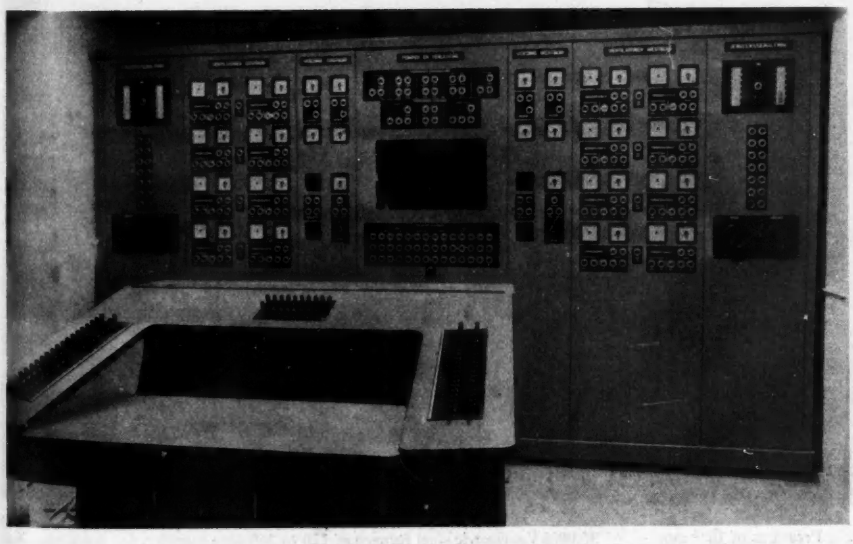
Next to the ship canal, a circular cofferdam was built and a short length of the tunnel constructed within its cover. Then this completed section was covered over, buttressing the canal side of the cofferdam, so that piles on the landward side could be withdrawn, and a connection made with the open cut construction. Later on, the canal was diverted over the completed section of the tunnel, and a cofferdam opened on the other side of it. The steel sheet piles of the circular cofferdam can be seen in the lower illustration opposite with the North Sea Canal in the background. The railway tunnel is to the right in this illustration. The dual carriageways of the road tunnel, with spaces for ventilation and services, may also be noted.

Large rail-mounted travelling shutters were characteristic of the work at Velsen, as may also be seen from the illustration. The ventilation plant is being built above the tunnel, and the ventilation plant on the opposite bank can also be seen, at a more advanced stage. One of the completed ventilation buildings is also illustrated, as is the control room.

Apart from the special interest in the purely civil engineering side of its construction, the road tunnel of the Velsen tunnel also makes noteworthy contributions to the design problems of illumination, especially in the transition lengths at each end. This problem also was referred to in our earlier article. The tunnel was designed by the directorate of locks and dams of the Rijkwaterstaat and the main contractor was N.V. Amsterdamsche Ballast Maatschappij.



**One of the ventilation buildings of the road tunnel at Velsen. The high shafts are for discharge air and the low shafts for the intake of fresh air**



**Control room of the Velsen road tunnel**

## Atomic Energy in Austria

Since the formation in 1955 of an Advisory Governmental Commission to deal with questions of atomic energy, and particularly since the further impulse given by the First Atomic Energy Conference which was held in Geneva in August of that year, nuclear energy has received increasing attention in Austria. Following discussions between the "Fund for peaceful atomic development," New York, and Austrian reports, the conclusion was reached that the construction of an Austrian reactor centre had become necessary. A research and study organisation, the Oesterreichische Studiengesellschaft G.m.b.H., was founded in May of last year, followed a month later by the signing of the standard bilateral atomic agreement with the U.S.A. In the Studiengesellschaft, which has a capital of 6,240,000 schillings, the State owns 50·48 per cent of the shares, and industry and commercial interests the remainder. The board of directors is composed of twenty-seven members, of whom fourteen are appointed by various ministries, twelve by industry, and one is appointed by scientific bodies.

This organisation has put forward plans for the training of specialists and has set up seventeen working parties in which over 300 university scientists and experts from industry and from the administration, are co-operating. The most important of these working parties are those for the research reactor project, training, biology and medicine, chemistry, industrial equipment, nuclear power projects, agriculture and forestry, metallurgy, patents and licences, law, &c.

A long-term reactor programme has been proposed, which would involve as a first step the erection of a research reactor of the "swimming pool" design, with a thermal capacity of 5MW and a neutron flux of $10^{13}$ neutrons per square centimetre per second. Besides laboratory installations, a 3MeV Van de Graff generator, and a 50MeV particle accelerator are to be set up. The metallurgical and chemical laboratories are to have a double hot cell for dealing with radiations up to 10,000 curies. A separate installation for gamma irradiation will be erected. Construction of the centre is to be started towards the end of this year. Total cost is estimated at 100 million schillings. About 120 scientists will be employed.

A second reactor is to be built on behalf of the Ministry of Education, for the training of young scientists and for basic research.

## Passenger Vessel "France"

It has been announced that the keel of the new passenger vessel "France" (55,000 gross tons) was officially laid at St. Nazaire on October 5. The "France" is being built by the Chantiers de l'Atlantique Penhöet-Loire, on the slipway that was used for the construction of the "Normandie." The vessel will be operated by the Compagnie Générale Transatlantique on the Havre–Southampton–New York service.

The principal data of the vessel, which is the largest passenger ship at present under construction, are stated to be : length, 984ft ; breadth, 108ft 3½in ; depth, 78ft 10in ; draught, 32ft 10in. There will be nine decks and a double hull subdivided into fifteen main compartments by watertight bulkheads.

An installed service power of about 150,000 h.p. is to give the ship a speed of 30 knots. The propulsion machinery will be housed in two separate and independent compartments. Each of the four propeller shafts will be driven by four single geared CEM-Penhöet turbines (one high pressure, two intermediate pressure, and one low pressure).

Steam will be supplied by eight water-tube boilers at 70 kg per square centimetre and superheated to 480 deg. Cent. Bunkers totalling 8660 tons will hold sufficient fuel for the return trip Le Havre–New York. Fresh water will be supplied for the boilers and ship's services, by four groups of low-pressure evaporators, at the rate of 300 tons per day. Two independent groups of generators, totalling 12,000kW, will supply electrical energy at 440V, 60 c/s. The vessel is to be fitted with Denny Brown gyro-stabilisers.

## East German Nuclear Power Plant

According to East German broadcasts quoted in the German press, preliminary work for the first East German atomic power station has begun on a secret site north of Berlin. A 6km access road, a rail spur, and a housing estate of 200 flats have been constructed, and site clearance for the station buildings is in progress. The station is to have a capacity of 70MW, and an annual uranium consumption of "a few tons." It is to come into service in 1960. Radioactive fission products are to be stored in special containers, and as a safety measure a zone of 3km radius around the station will be kept clear of habitation and withdrawn from agricultural use.

## Nuclear Energy Standards

What may well be the first instance in the history of technology to secure international agreement on standard practices before national usage has become hardened is the attempt now being made to establish agreed world standards in the field of nuclear energy.

The work is being undertaken by a committee of the I.S.O. (International Organisation for Standardisation), whose first meeting took place in Geneva in July. This meeting, which was attended by sixty-one delegates from fourteen countries, led to the decision to produce a preliminary draft of standard recommendations on methods of ensuring reactor safety and personal safety, and on an agreed "international language" of nuclear terms. While it is not concerned with the design and technical development of nuclear equipment, the committee is now preparing a programme aimed at facilitating trade between countries in installations for, and the products of, nuclear energy. Delegates came from Belgium, Finland, France, Germany, Hungary, Israel, Italy, Japan, Netherlands, Poland, the United Kingdom, United States, U.S.S.R. and Yugoslavia. In addition, observers were present from Brazil, Greece, India, Sweden and Switzerland, as well as from seven major international organisations having a close interest in nucleonics, such as the International Labour Organisation, World Health Organisation and International Electrotechnical Commission (I.E.C.).

The new I.S.O. committee divided into three working groups which will become permanent sub-committees, and between them will deal with the following projects: development of a glossary of nuclear terms in English, French and Russian; approval of a warning symbol for use wherever danger from ionising radiation is present; adoption of units pertaining to nuclear energy developed by the International Commission on Radiation Protection and the International Commission on Radiological Units; drawing symbols, and recommendations relating to the measurement of and protection against radiation, as well as the development of internationally acceptable guides for safe design, operation and maintenance of nuclear reactors.

## Vacuum Melting and Casting Furnaces

We have received details from the maker, Heraeus G.m.b.H., Hanau, of its "VA-JS" vacuum melting and casting furnaces, of which the smallest, the "VA-JS 2," is shown in the accompanying illustration. Specially designed for use in metallurgical laboratories, the furnace has a useful crucible capacity of 2 litres. It can be used as required either as a tilting furnace or for bottom tapping with a mechanically operated plug. Like the other furnaces of this series, the "VA-JS 2" is made in three versions, which differ in the pumping equipment. Version I is suitable for cases where much gas is given off, with a terminal vacuum of $10^{-3}$mm Hg; version II can reach a terminal vacuum of $10^{-5}$mm Hg. with large gas volumes only occurring at pressures lower than $10^{-3}$mm Hg. The furnaces equipped according to version III are stated to be suitable for terminal pressures below $10^{-6}$mm Hg, and where evolution of gas takes place over the whole range of pressures.

The containers are made of non-magnetic stainless steel, resulting in good vacuum conditions and a minimum of electrical losses. The polished internal surfaces can easily be kept clean. All vacuum controls are electrically operated so that faulty manipulation can readily be excluded by suitable interlocks and the formation of explosive gas mixtures is prevented. Vacuum valves were installed at the fore-pump side to avoid the danger of contaminations getting into the valves, and to obviate the need for very large valve diameters.

Measuring equipment varies according to the pressure range involved, diaphragm gauges, thermo-electric gauges, or ionisation gauges, being used as required. Material can be added through an air lock while the furnace remains under a vacuum. Ingot moulds can be fitted externally so that long wire-bar moulds can be used.

## Electric Steel Furnace

We illustrate below an electric arc furnace of 120 to 140 tons capacity which was installed by Demag A.G., Duisburg, in the Hüttenwerk Rheinhausen (Niederrhein) steel plant. The furnace is intended to produce plain carbon steel in open hearth quality. Its lid is hydraulically operated, with hydraulic weight compensation, and can be swung to one side, as illustrated. Under the lid may be seen the ends of the three graphite electrodes which have diameters of 600mm.

With a transformer capacity of 36,000kVA, the furnace is stated to be the largest of its kind in Germany. The voltage ranges between 120V and 500V.

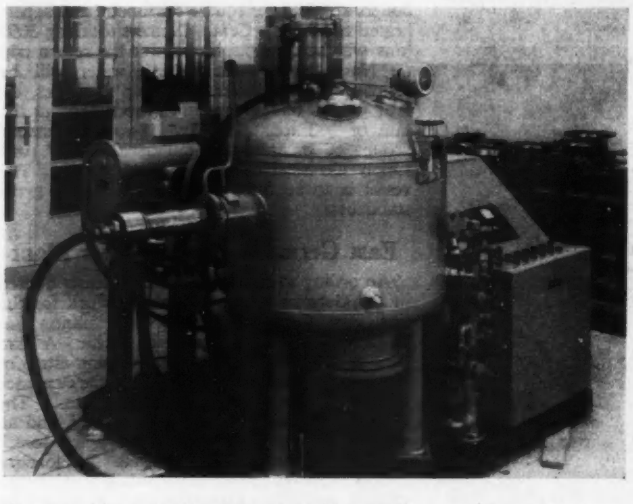
The rotatable crucible has a diameter of 7200mm and is equipped with two doors for facilitating the removal of slag and also for maintenance purposes. The charge consists entirely of scrap and takes 130 minutes to melt, requiring an amount of energy of 400kWh per ton. Total consumption is 530kWh per ton of molten steel. For a furnace of this kind a melting capacity of over 26 kg per minute is high and is said to have previously been reached only by small furnaces. Hourly output is at the rate of 23 to 25 tons, corresponding to four and a half melts every twenty-four hours.

## Standard Signalling System for Inland Waterways

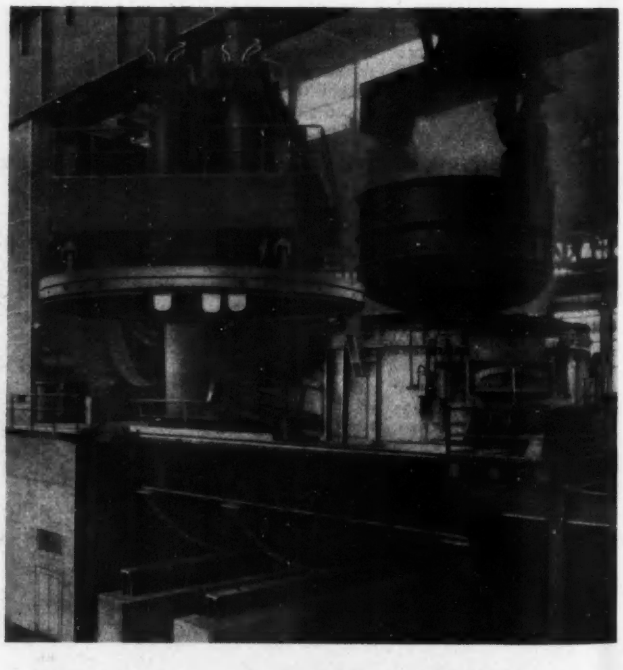
The Sub-Committee on Inland Water Transport of the United Nations Economic Commission for Europe (ECE) recently held its first session in Geneva. It urged governments to adopt as rapidly as possible a European standardised system of signs and signals on their unisolated waterways, in order to reduce accidents and avoid confusion. At present, no uniform system of signalling exists. Although signalling within a certain basin such as the Rhine Basin or the Danube Basin is uniform, there are several differences between the signs and signals used by various countries on their national waterways systems or on certain international riverways.

The sub-committee therefore discussed a report drawn up by a group of experts which began its work in 1954 under the auspices of the Permanent International Association of Navigation Congresses and the ECE Inland Transport Committee. The first part of the task entrusted to this group of experts—signalling on the waterways themselves—was completed at the end of 1956. The six parts of the report cover "General Provisions"; "Buoyage of Waterways"; "Signalisation of Works"; "Dams"; "Special Signals, including, among others, Mandatory Signs, Prohibitory Signs and Informative Signs"; and "Other Provisions." After some minor modifications, the report was adopted by the sub-committee. In view of the lengthy procedure for bringing conventions into force and also the difficulty of amending them subsequently, the sub-committee decided to bring the recommendations into force by means of a resolution, urging governments to introduce those waterways within their territories which do not constitute a completely isolated network the signalling system agreed upon by the sub-committee, and to abolish as quickly as possible the use of signals which do not conform to the system laid down by it. Machinery has been set up to deal with questions which may arise in the implementation of this resolution, Work will now continue on rules of the road and on optical and auditory signals on ships.

The sub-committee also had before it reports drawn up by experts from various countries on mechanising the loading and unloading of cargoes in river ports. Owing to the large number of problems concerned it was decided that priority should be given to the study of questions of transhipment of goods in bulk, since that kind of goods accounts for the major part of all freight traffic on inland waterways.



Vacuum melting and casting furnace for 2-litre crucibles. Pressures of $10^{-5}$ mm Hg and less can be reached

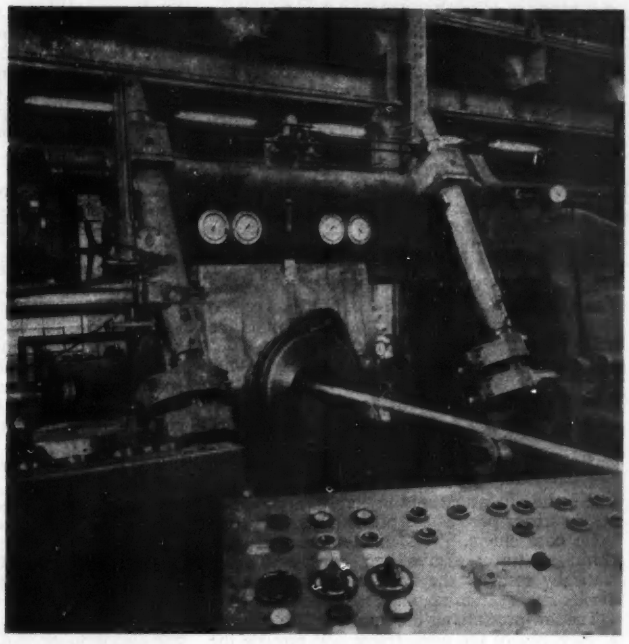


36,000kVA electric steel furnace of 120 to 140 tons capacity, for the production of plain carbon steel from scrap

# Application of Aluminium Sheaths to Electric Cables by Direct Extrusion

BY OUR AMERICAN EDITOR

*For the past ten years the General Cable Corporation watched and studied the progress of the various methods of applying aluminium sheaths to electric cables. After having carefully observed and analysed the methods of longitudinal folding and welding of aluminium strip into a cable sheath and that of inserting cable cores into oversized extruded tubes and the subsequent die sinking or helical corrugating of these tubes to fit the cable core, the firm decided to concentrate its attention on the development of applying aluminium sheaths by the direct extrusion method. The 1600-ton cable sheathing press at the company's Perth Amboy works is described here.*



FOLLOWING earlier work by such firms as Felten and Guilleaume in Germany and British Insulated Callender's Cables in England, the General Cable Corporation, of New York, became interested in the application of aluminium sheaths to electric cables. Initially, several installations of experimental and commercial aluminium cable sheathing machines were observed in Germany and England. After having seen sufficient evidence that aluminium sheathing by direct extrusion could be performed successfully, a 1600-ton aluminium sheathing extrusion press was ordered from Schloemann A.G., of Düsseldorf, in the spring of 1954. The principal purpose of the new plant was to enable the General Cable Corporation to make available to its customers in the United States directly extruded aluminium sheathed cables with controlled temper and in lengths not limited by the aluminium sheathing process. The construction of this press was completed in the middle of 1955. This unit was then temporarily installed in Germany for test runs and evaluation as a joint venture between the General Cable Corporation and Schlœmann A.G. Paper and rubber insulated cables ranging in diameter from less than ¼in to more than 2in were sheathed on the small die block, which was installed for this evaluation, with commercially pure (99·5 per cent) aluminium at high temperature in continuous lengths, without damaging the cable insulations and without air blisters. After several months of trial runs and successful performance, the press was dismantled and has now been installed at the firm's Perth Amboy works.

The installation consists of the following principal parts: extrusion press and attached billet loading devices; pump assemblies; low-pressure accumulators for inserting of heated billets into containers; high-pressure piston accumulator for upsetting of billets and withdrawing of rams; oil supply, circulating and filtering system; electro-hydraulic controls; master control station; electric substation and switchgear; induction furnaces for billet heating; water treating, cooling and recirculating system; take-up and pay-off stands; caterpillar capstan with corrugating and die sinking unit.

Technical data relating to the installation are listed in the accompanying table.

The extrusion press is a horizontal double-piston, double-billet unit of 1600 tons capacity, designed for the use of commercially pure (99·5 per cent) aluminium. The press frame is a one-piece rectangular steel casting weighing approximately 100,000 lb. This design eliminates the necessity for columns which are used on conventional presses built in the United States. The ends of this frame are bored to accept two hydraulic cylinders and rams. The exposed ends of the hydraulic rams with the attached extrusion rams are mounted in cast steel yokes, one for each ram, to which are bolted adjustable guide shoes, and these shoes are carried on rails which are attached to the bottom of the press frame. This guide assembly facilitates the proper alignment of the extrusion rams with the billet containers. Each ram is separately operated by individual control systems.

*Particulars of Press for Aluminium Sheathing of Cables*

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| Press capacity | 1600 tons |
| Operating pressure of press, pumps and piston accumulator | 4600 lb per square inch |
| Operating pressure of air accumulator and air compressor | 225 lb per square inch |
| Diameter of hydraulic ram | 33in |
| Maximum stroke of hydraulic ram | 39in |
| Aluminium billet size | 7in diameter by 18in long |
| Weight of two aluminium billets per charge | 126 lb |
| Extrusion material | Commercially pure aluminium (99·5 per cent) |
| Extrusion pump capacity | 2 × 110 litres per minute each, in 31 steps of approximately 3·6 litres per minute |
| Expandable high-pressure accumulator capacity | 150 litres |
| Accumulator pump capacity | 56 litres per minute |
| Aluminium extrusion rate | 0 lb to 63 lb per minute in 31 steps |
| Billet heating furnaces | 2 of 195kW each |
| Container heating furnaces | 2 of 45kW each |

The die block assembly is mounted at the centre of the frame. This assembly consists of the die block, two billet containers mounted on opposite sides of the die block adjacent to the extrusion rams, a cooling system to protect the cable core and cool the extruded sheath, and an adjustable die holder for opening or closing the spacing between the die and core die to regulate the wall thickness of the aluminium sheath while the press is in operation or stopped. This adjustment of the die holder is controlled by a large "ratchet spanner" which is operated by a double-acting hydraulic cylinder. The billet containers are mounted on the same centre line as the extrusion rams, and the centre line of the die block is at right angles to the centre line of the containers. The centre lines of the die block, rams and containers are all in the same horizontal plane. The "ratchet spanner" is mounted concentrically with the die assembly on the die block at the extrusion side. The hydraulic cylinder which operates the spanner is, in turn, mounted on the lower part of the press frame.

The die block and extrusion tools used in the aluminium press are similar to those used in the conventional lead sheathing press. The double-ram design is instrumental in keeping the cavity in the

**Fig. 1—1600-ton Schlœmann aluminium sheathing press installation at the Perth Amboy works of the General Cable Corporation**

die block very small. Because equal pressure is applied from opposite sides of the die block, equal radial pressures are built up against the die and core die so that a radial displacement of the tools in the die block is prevented. By means of this design the flow of aluminium is greatly facilitated. Both the core die and die are inserted and removed from the cable discharge side of the press. A water cooling device is used at the cable entrance side of the die block to protect the cable insulation from the high temperature of the die block and core die by cooling the core die, the aluminium and the air adjacent to the unprotected insulation between the core die and die. On the cable exit side of the die block is a second water cooling device which is designed and placed to cool the sheath effectively and to protect the cable core after it has been extruded.

Two automatically controlled billet loading devices are mounted on the upper part of the press frame facing the extrusion side. As shown in Fig. 1, each loading mechanism consists of two hydraulically operated swinging arms, and each arm has a clamping device to carry and place into position the heated aluminium billets. The hydraulic synchronising control is mounted on the upper part of the press frame where the cable core enters. This unit ensures the synchronised travel of the two rams and automatically controls the uniform average rate of displacement of aluminium in each container.

The low-pressure air accumulators are situated at each end of the press frame and provide the power for the rapid forward motion of the rams and the inserting of billets into the containers. The high-pressure piston accumulator furnishes the energy for the " upsetting " of billets and the consequent displacement of air from the charged containers, which prevents air blisters in the extruded sheath. This high-pressure accumulator is also utilised for the rapid withdrawal of the rams after the billets have been extruded. The actual extrusion of the aluminium sheath is powered by a combination of fourteen constant-volume pumps of various capacities ; seven of these pumps are connected directly to each cylinder, and each pump operates at a pressure of 315 atmospheres (4600 lb per square inch).

The movement of the extrusion rams is controlled by the main control valve station which is mounted under the press. The individual valves of this assembly are opened and closed by cams which are positioned through an electronically regulated servo-mechanism activated from the pilot control of the master control station.

The extrusion speed of the aluminium sheath is controlled by a rotary port valve mounted at the master control station. The outlets of the high-pressure extrusion pumps are connected by pipe to a control valve station and a single pipe connection is run to each hydraulic cylinder on the press. Each valve in this station is equipped with a pilot control valve. These pilot valves are connected to the speed-regulating control at the master control station, and the pressure required to open and close the valves is supplied by an individual control pump. By the operation of the speed regulator at the master control station any of thirty-one increments of extrusion speed can be selected. This regulator is a rotary valve with a series of ports that are arranged to open and close the main valves between the extrusion pumps and the hydraulic cylinders. The capacity of each set of seven pumps is 110 litres per minute and this output can be controlled in thirty-one steps of approximately 3·6 litres per minute.

Two low-frequency induction furnaces, each rated at 195kW, for heating the aluminium billets are situated at the exit side of the press symmetrically to the die block assembly. The aluminium billets are placed on inclined storage tables, from which they are automatically released and rolled on to transfer trays and then pushed forward through the induction coils of the furnaces. As the billets emerge from the heaters, after having been heated to 500 deg. Cent., they are automatically transferred to tables consisting of three rolls shaped to support the billets with a minimum of surface contact. Mounted on each table is a combination screw-operated pusher and water spray. The position of the pusher is such that it is concentric with the billet on the table. Directly in front of the billets on the table and also concentric with the billets are positioned the clamping devices of the two billet loading arms. As the billets are transferred to the table rollers the pushers are automatically activated and move forward, placing each billet into its corresponding swing arm. The billets are then sprayed with water to reduce the temperatures of the ends facing the extrusion ram to 400 deg. Cent.

The master control station is equipped with all of the necessary controls to operate the press and also with signal lights which indicate the proper operation of the auxiliary heating and pumping equipment. Ease of operation is accomplished by grouping the controls and signal lights which pertain to the operation of an individual unit, such as the servo-mechanism for the main control valve station, the transfer of billets through the induction furnaces into the billet loading swing arm, the induction heating of billets, the water sprays for cooling one end of each billet, the induction heating of the containers, &c. These controls provide for either automatic or manual operation.

The oil of the hydraulic system must be clean and free from foreign particles, and the hydraulic pressure of 4600 lb per square inch necessitates close tolerances between any two moving parts. Therefore all welded parts of the circulating system, such as the pipes and tanks, were pickled, neutralised and flushed after the fabrication of sub-assemblies and before final installation, to remove any foreign particles. During the operation of the press the oil is constantly circulated and filtered. The oil storage and circulating system consists of three tanks : an upper or high-level tank from which the oil is fed to all equipment by gravity ; a lower oil tank for make-up and oil conditioning ; and a leak oil or sump tank. The upper and lower oil tanks are closed and sealed against air except for one opening in each tank, in which air filters are installed. The function of the upper oil tank is to supply all the high-pressure pumps and the high-pressure accumulator, which is fed through a magnetic filter to remove iron particles that may be present. The oil is fed through the pumps to the various units during operation and returns directly to the upper oil tank. Oil accumulated in the leak oil tank is also returned to the lower oil tank through a filter system. Thus the oil is constantly being circulated and filtered between the upper and lower tanks. A further function of the lower oil tank is to supply oil to the low-pressure accumulators.

A take-up stand, which accommodates large-diameter reels, is mounted at the cable exit side of the extrusion press. The position of the take-up is adjustable for a distance of 20ft to 70ft from the press. Interposed between the press and the take-up stand are a caterpillar capstan and a corrugating roll stand or die-sinking stand, as required. With this auxiliary equipment the following kinds of cables can be produced in one operation : (*a*) directly extruded aluminium sheathed cables ; (*b*) die-sunk aluminium sheathed cables ; and (*c*) corrugated aluminium sheathed cables.

*Cooling of Cable.*—The cable passes through the die block horizontally and perpendicular to the direction of the motion of the extrusion rams. The die block is situated between the two billet containers, which are equipped with the low-voltage, low-frequency induction heating units. The cable core, upon entering the die block and core die, is protected from the high temperature of the die block by means of a specially designed water-cooled tube assembly. The end of this water-cooled tube assembly is in positive pressure contact with the core die. On the cable exit side of the press the cable sheath is uniformly sprayed with water around its circumference near the point of exit from the die. To obtain effective cooling it is essential that the cooling device be brought as closely as possible to the die without chilling the die. Chilling of the die itself would increase the extrusion pressure, and it is therefore essential that only the extruded aluminium sheath be cooled.

The removal of heat by the two cooling devices on the core and sheath side of the cable is so effective that even though the aluminium is extruded at a temperature of 500 deg. Cent the surface temperature of the aluminium sheath after leaving the cooling tube is less than 60 deg. Cent. The temperature time schedule to which the cable core is exposed in this press thus is not more severe than that in a conventional lead press.

As the extrusion cycle nears its completion it is important to reduce the extrusion speed slowly during the last half minute before a full stop is reached. This gradual deceleration of the extrusion speed is accomplished by built-in pressure reliefs in the hydraulic system. During this slow-down period the cooling effect on the extrusion side reduces the die temperature, and once a full stop has been reached the die itself is sufficiently cooled to absorb the heat from the annulus of aluminium between the die and the core die and from the " bamboo ring " or press stop mark section of the sheath so that damage to the cable core is prevented. It is possible, on a purely thermal basis, to have stopping periods as long as desired without damaging the insulation of the cable core. The stopping period of the press for the purpose of charging billets is about one minute. During the operations of the press paper-insulated cables have remained in the press for periods of five minutes and longer without damage to the insulation. The degree of cooling can be adjusted by changing the spacing between the cooling unit and the die, and this arrangement makes it practicable to obtain temperature conditions similar to those prevailing in a lead press.

*Billet Charging Practice.*—As a primary requisite it is essential that the as-cast aluminium billets be free of internal defects. Furthermore, because the as-cast billets have rough surfaces and contain surface inclusions, it is necessary to remove these imperfections before the billets are charged into the press. The billets must be machined into a true cylindrical shape with smooth surfaces and flat ends and be free of surface inclusions. The diameter and length must be accurately controlled within the required tolerance limits. When billets are charged into the containers of the press, it is essential that the clearance between billets and containers be as small as possible. Any air entrapped in the containers would appear as blisters or perforations in the cable sheath. By placing accurately dimensioned billets with smooth surfaces into the containers there is a minimum of air volume present. If the inserted billets were uniformly heated over their entire lengths, the billets would expand under ram pressure at the centre sections before their ends expanded, and air would be trapped between the centre sections of the billets and the aluminium remnants left in the containers. This trapped air would be considerably compressed and, when transferred into the extruded sheath, would cause blisters and perforations.

A fundamental and important technique for preventing air inclusion in the finished sheath is the development known as " upsetting." The billets heated to 500 deg. Cent. are thermally " tapered " by chilling one end to 400 deg. Cent. This " tapered " heating of billets creates a differential of plastic deformation between the ends of the billets during upsetting. The chilled section of the billets facing the rams have greater resistance to deformation, and, when ram pressure is applied against the billets, they are changed from the cylindrical shape into a conical shape. This deformation advances toward the ram until the billets have been transformed into a cylindrical shape fitting tightly into the containers. This conical " upsetting " of the billets takes place in a few seconds and displaces the air from the containers and prevents air inclusions or blisters in the sheath. The company feels that the use of properly cast billets with smooth surfaces, the " tapered " heating of billets and the precise control of " upsetting " of the billets in the containers into conical form has made it possible to extrude aluminium sheath reliably without air blisters or perforations.

*Sheath Thickness Control.*—During the extrusion of the sheath, the aluminium in the die block is under considerable pressure, and this pressure is transferred to the die and core die. In a full operating cycle, from the time extrusion is stopped, the rams are withdrawn, new billets are inserted and extrusion is resumed, the pressure acting upon the die and core die as well as upon the annulus of aluminium approaching formation of the sheath alternates over a wide range. When the pressure is released from the annulus

through the relief of pressure in the hydraulic cylinders, a reduction in the wall thickness of the sheath is caused. Simultaneously, both the die and core die, being relieved of pressure, exert additional force on to the press stop mark or "bamboo ring" section. The higher the pressure differential the more pronounced is the "bamboo ring." The design of this press and its tools, and extrusion at high temperature aid in the reduction of the extrusion pressure and minimise the pressure changes that occur at the dies and form the "bamboo ring."

In addition to the elastic changes created by pressure variations, there is the thermal effect of the intensive cooling of the core die, the die and the extruded sheath; these factors further aggravate the shrinkage at the "bamboo ring" and its adjoining sections. The two effects of elastic expansion and thermal transfer have been compensated for by the introduction of a hydraulically operated "ratchet spanner," which facilitates the opening and closing of the spacing between die and core die and compensates for the change in thickness of the sheath when the press is stopped. This operation is done by the opening or closing of a threaded section which supports the die. This technique helps to adjust the wall thickness while the press is in operation, to relieve the pressure between the die and the core die when the press is stopped, to compensate for the cooling of the die and core die which causes the shrinkage of the aluminium when the press is stopped, and to permit the proper control of wall thickness at the "bamboo ring" section.

*Operation of Extrusion Press.*—The two induction furnaces for billet heating work in parallel; each furnace carries three billets and heats them to a temperature of 500 deg. Cent. A signal at the master control station indicates to the operator when the billets have reached the required temperature. The billet transports are energised by operating a push button at the master control station and the billets are discharged from each furnace. The billets are then rolled out of the stainless steel transfer trays which carry them through the furnaces and are placed in front of the screw-operated pushers which move the heated billets into the billet holders or clamps of the hydraulically operated swinging arms mounted on the press. During this cycle a new supply of billets is rolled from the holding tables on to transfer trays, forwarded into the induction furnace to start another heating cycle. Less than one minute before the billets are to be swung into the press a second push button is operated which starts the water sprays of the screw-operated pushers and cools one end of each billet from 500 deg. to 400 deg. Cent. After this cooling cycle is completed, the hydraulically operated swinging arms of the billet loaders automatically place the "tapered-heated" billets in front of the press containers. This swinging motion can only take place after the extrusion rams have been fully withdrawn and safety interlocks, which are operated by the withdrawn rams, activate the swinging arms.

By turning the servo-mechanism controls at the master control station into the position "advance" the low-pressure air accumulator activates the two rams of the press and inserts the "tapered-heated" billets into the containers. The advance of the rams energises the opening of the clamps of the swinging arms, which previously held the billets, returning the swinging arms to their original position. The predetermined sequence of individual operations in this cycle are ensured by interlocking controls. Billets can also be advanced and charged by manually operated remote controls; in this case, too, the various interlocks will prevent setting into motion any operation not in proper sequence which could cause interference and damage the equipment.

The high-pressure accumulator can be actuated to "upset" the billets only after the hydraulically operated swinging arms have been moved outwards. By turning the servo-mechanism control at the master control station from "advance" to "upsetting" both rams are moved quickly by the high-pressure accumulator. The pressure for "upsetting" is controlled by relief valves in such a way that the billets are tightly compressed in the containers between the rams and the aluminium butts left in the containers from the previous charge, without actually starting any extrusion of cable sheath. This action causes the displacement of the air in the containers. After upsetting the billets, which takes a few seconds, as described above, the servo-mechanism control can be turned to the "press" position and the speed regulating control may then be operated. About one minute before completing an extrusion cycle, the next pair of billets is released from the furnaces through push-button control. The working cycle described above is then repeated. As the extrusion rams approach the end of their travel the extrusion speed is gradually reduced until the sheathed cable is brought to a stop.

After completing the extrusion cycle the by-pass valves of the pumps are opened and the supply of oil to the press cylinders is stopped. The cylinders retain the high pressure which is reduced only gradually. Under this residual pressure, after the pumps are by-passed, there is still some cable sheath extruded, until an equilibrium is reached between the extrusion resistance and the extrusion pressure, and only then the extrusion speed is reduced to zero. At the point where extrusion stops, the pressure in the hydraulic cylinders is about 2500 lb per square

**Fig. 2—Section of 2 5/16in diameter × 0·070in wall thickness extruded aluminium tubing. Magnification 7×**

inch with corresponding pressures in the die block. The full relief to zero is controlled by relief vents over a period of several seconds. During this period the "ratchet spanner" is operated to increase the spacing between the die and the core die, thus increasing the wall thickness of the "bamboo ring" as well as the adjacent few inches of the sheath. This adjustment compensates for the thermal and elastic changes which occur because of the cooling of the aluminium and the drop in pressure when the extrusion comes to a halt. After the pressure has dropped to zero the servo-mechanism control is turned to the "withdraw" position and the rams are moved back by the high-pressure accumulator. With the rams in the retracted position an interlock switch energises the swinging of the billet loading arms into the press position. The billets are then again inserted into the containers, the loading arms swung into outward position, the billets "upset" and extrusion is resumed at a slow rate. At this point the "ratchet spanner" is operated, decreasing the spacing between the die and core die. This adjustment is made over a distance of several inches of extruded sheath and the final position of the tools is set after the hot metal has displaced the cooled metal between the die and core die. By this die adjustment the shrinking of the cable sheath at the "bamboo ring" section is compensated for. Shortly before the completion of the extrusion cycle the "ratchet spanner" is again actuated, increasing the spacing between the die and core die.

The successful operation of this extrusion press requires that the two extrusion rams simultaneously reach predetermined points in the containers at the end of each stroke. A control is therefore provided to synchronise and equalise the movement of the two rams to compensate for the minor differences in the volume of aluminium of the individual billets and for the minor differences in the temperature between the "tapered-heated" billets. An uneven advance of the rams is shown by a magnified indicator situated in the centre of the press, and by activating the built-in equaliser this movement is corrected and the advance of the two rams is automatically synchronised. This synchronising action of the extrusion rams is an essential part of the press construction.

To illustrate the quality of the welded sheath, we reproduce in Fig. 2 a section of 2 5/16in diameter by 0·070in wall thickness aluminium tubing which was extruded on the 1600-ton press at Perth Amboy. This sample was deeply etched in NaOH to outline the charge weld obtained.

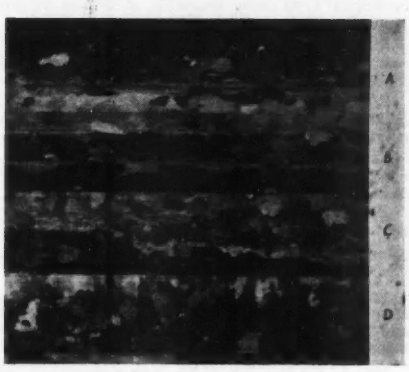



**Fig. 3—Longitudinal and transverse sections of 2 5/16in ×0·070in extruded aluminium tubing. Magnification 7×**

Fig. 3 is a combination of four sections of the same charge weld: *A* and *B* are longitudinal sections, while *C* is a transverse section of the weld. These samples have been anodically etched to develop the grain structure. It should be noted that the weld is metallurgically sound and can be delineated only by the grain orientation difference between the old and new charge material. Section *D* is a transverse section taken to include the die or seam weld. The etchant used was 1·8 per cent fluoboric acid.

The installation of the aluminium sheathing press was made under the direction of Mr. Oscar G. Garner, Vice-President of the General Cable Corporation, who also supplied the information for this article.

## Foreign Orders for American Gas Turbines

FIVE gas turbine units recently were ordered from the International General Electric Company. One will be delivered to France, two to Colombia and two to Venezuela. All five units will be manufactured by the General Electric Gas Turbine Department, at Schenectady, New York. The French order constitutes the first American gas turbine to be ordered for use in Europe. This 7850 h.p. simple-cycle, two-shaft unit will be installed in the Normandie refinery of the Compagnie Française de Raffinage. It will be used to convert a waste by-product into both mechanical and thermal energy. The machine will operate on "tail gas," a waste product of the refinery. The gas has a heating value of 500 B.Th.U. per cubic foot and will be mixed with the air compressed by the axial-flow compressor and burned in the six combustion chambers of the turbine. The combustion gases will pass through the two-stage turbine, which will drive propane and ethylene compressors integrated with the refinery process and then will be piped through a heat recovery boiler to produce about 30,000 lb per hour of process steam.

The two 7500kW gas turbines ordered by the Industria Colombia de Fertilizantes, S.A., of Colombia, are of simple-cycle, single-shaft design and will use natural gas as fuel. Finally, the Creole Petroleum Corporation of Venezuela has ordered two 8700kW gas turbine-generator units to be installed in its Amuay refinery. These machines are also of simple-cycle, single-shaft design, and will be used to provide electric power for the refinery's process operation. They are adaptable for burning either natural gas or distillate oil and are designed for automatic change over from one fuel to the other.

# Personal and Business

## Appointments

BRITISH PLIMBER, Ltd., has announced that Mr. E. Lyle Pixton has been appointed managing director.

DR. JAMES REEKIE, A.M.I.E.E., has been appointed chief engineer to Semiconductors, Ltd., Ilford, Essex.

MR. CHARLES K. TURNER-HUGHES has been appointed chief sales executive of Simms Motor Units, Ltd.

MR. ERIC E. PRATT has been appointed commercial manager in the electronics and equipment group of the Plessey Company, Ltd.

FERRANTI, Ltd., announces that, in view of Mr. A. Ridding's illness, Mr. R. K. Saunders has been appointed instrument sales manager.

THE UNITED CONSTRUCTION MACHINERY COMPANY, Ltd., has announced that Mr. W. R. R. Husser has been appointed a director.

JOHNSON AND PHILLIPS, Ltd., announces that Mr. William Glass, M.I.Mech.E., has been appointed chairman in succession to Mr. G. Leslie Wates, Comp. I.E.E.

JOHN BROWN AND CO. (CLYDEBANK), Ltd., announces that Mr. John Brown, B.Sc., naval architect and technical director, has been appointed deputy managing director.

MR. A. NEVILLE STACK has been seconded to the Marine and Industrial Section of A.C.V. Sales, Ltd., in the capacity of deputy to Mr. P. J. Sims, M.I. Mech.E., M.I.Mar.E., who is manager of the section.

DEWRANCE AND CO., Ltd., announces that Mr. F. F. H. Halestrap, a director of the company, has retired after fifty-nine years' service. Mr. J. W. Plowman and Mr. D. Handley have both been appointed directors.

MR. G. HONNORATY has been appointed Midland regional manager of the A.E.I. Lamp and Lighting Company, Ltd., in succession to the late Mr. R. P. B. Voaden. Mr. H. G. Lilley has been appointed deputy manager of the lighting department.

THE MINISTRY OF SUPPLY has announced that Mr. P. A. Hufton has been appointed head of aerodynamics department, Royal Aircraft Establishment, Bedford, and that Dr. D. Kuchemann will succeed Mr. Hufton as head of supersonics division, aerodynamics department.

THE BRUSH GROUP has announced that Mr. P. H. W. Everitt, M.I.Mech.E., and Mr. A. J. Haselfoot, A.M.I.E.E., have been appointed directors, and Mr. D. N. Dow, company secretary of Fuller Electric, Ltd. Mr. L. Berry has been appointed company secretary of Mirrlees, Bickerton and Day, Ltd.

MR. J. A. MILNE, chairman and managing director of J. Samuel White and Co., Ltd., has been elected president of the Shipbuilding Conference in succession to Sir James N. McNeill. Colonel T. Eustace Smith, chairman and managing director of Smith's Dock Company, Ltd., has been elected vice-president.

SMITH'S DOCK COMPANY, Ltd., has announced that Sir Thomas D. Straker-Smith and Mr. James Patton have retired from the board and that Messrs. Peter G. Edwards and Anthony C. Macksey have been appointed directors. Mr. Patton has been succeeded as general manager at South Bank by Mr. C. E. Hunter.

THE SHIPBUILDING CONFERENCE states that Mr. J. A. Milne, the chairman and managing director of J. Samuel White and Co., Ltd., has been elected to succeed Sir James M. McNeill as president and that Colonel T. Eustace Smith, the chairman and managing director of Smith's Dock Company, Ltd., was elected vice-president in succession to Mr. Milne.

THE BRITISH ALUMINIUM COMPANY, Ltd., states that Messrs. W. H. Harrison and E. Holland-Martin has relinquished their directorships and that the following appointments have been made: Mr. G. A. Anderson, as director and general sales manager; Messrs. W. B. C. Perrycoste and J. Salter, as directors and general production managers; while Mr. G. W. Lacey, at present director in charge of sales, has become the commercial director.

## Business Announcements

WALLACE AND TIERNAN, Ltd., announces that it has acquired the share capital of E.C.D., Ltd., Tonbridge, Kent, manufacturers of proportioning pumps and other specialised equipment.

GRIFFIN AND GEORGE, Ltd., has announced that the address of its sales office and warehouse for the Birmingham area is Frederick Street, Birmingham, 1 (telephone, Central 2552). The telephone number of its Edinburgh office at Johnston Terrace is now Caledonian 4868.

WINSTON ELECTRONICS, Ltd., Shepperton, Middlesex, announces that it has been appointed sole United Kingdom agents for a number of industrial electronic control instruments manufactured by Beckman Instruments G.m.b.H., Munich, Germany, and Beckman Instruments, Inc., Fullerton, California, U.S.A.

KLOCKNER MOELLER ENGLAND, Ltd., has announced the opening of new offices on November 1. The new premises will be at Guildhall Buildings, Navigation Street, Birmingham, 2 (telephone, Midland 2891), and also at 451, Durham Road, Low Fell, Gateshead-on Tyne, 9, Co. Durham (telephone, Gateshead-on-Tyne 77035).

PERMALI, Ltd., Bristol Road, Gloucester, announces that, due to partial occupation of the new factory at Gloucester, the company now has more space at the existing works for the expanding manufacture of P.T.F.E. (polytetrafluoroethylene) products, which are to be sold under the newly registered name of "Permaflon."

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., states that Mr. R. A. R. Bottone, M.I.E.E., head of the industrial sales department at Crown House, has retired. He has been succeeded by Mr. F. C. Lucas. Mr. H. Orchard, M.I.E.E., M.I.Mar.E., who has for many years been engaged on the design of large d.c. machines, particularly for marine drives, has retired from the company after forty-five years' service.

## Contracts

THE BURTONWOOD ENGINEERING COMPANY, Ltd., Warrington, has received an order, from the Royal Dutch State Mines, for plastics machinery and fittings. The value of the order is put at £54,000.

JOSEPH SANKEY AND SONS, Ltd., Wellington, Shropshire, has received a contract from the National Institute for Research in Nuclear Science for the supply of 340 steel blocks, each weighing 20 tons, to form the magnet yoke in the 7000MeV proton synchrotron now being built near the A.E.R.E. at Harwell. The total cost is to be over £1,250,000.

METROPOLITAN-VICKERS ELECTRICAL EXPORT COMPANY, Ltd., has received an order for power generating equipment from the British Columbia Electric Company, Ltd., Vancouver, Canada, to supply four 150MW steam turbine generator sets and condensers and steam auxiliary equipment. Two more generating sets, of the same capacity and with similar condensers and associated equipment, will be ordered later; the total value of the contract will be 30,000,000 dollars. The first two generating sets will be commissioned in January and August, 1961. Messrs. Balfour, Beatty are consultants for the scheme. The generators will be hydrogen cooled, with hydrogen at a pressure of 30 lb per square inch gauge, and will generate at 16·5kV, three-phase, 60 c/s, 0·9 power factor. They will be direct coupled to turbines running at 3600 r.p.m. The turbines will be Metropolitan-Vickers three-cylinder, close-coupled, reheat machines, designed for initial steam conditions of 1800 lb per square inch, 1000 deg. Fah., with reheat to 1000 deg. Fah. A six-stage feed heating system will be employed, including deaerating plant, and the final feed water temperature will be 460 deg. Fah. The turbines and generators will be manufactured at the Metropolitan-Vickers Trafford Park works, and the condensing and feed heating plant at the company's Germiston works, Glasgow.

## Miscellanea

MR. H. M. MACMILLAN.—It is with regret that we record the death of Mr. Hugh Miller Macmillan, B.Sc., which occurred on October 4, at his home in Helensburgh. Mr. Macmillan was the chairman and managing director of the Blythswood Shipbuilding Company, Ltd., a company which he founded after the first world war, and which he has controlled throughout the thirty-eight years of its existence.

TRAINING SCHOOL.—The "Potterton" division of Thomas De La Rue and Co., Ltd., has opened a training centre at 18, Kenilford Road, Balham, to provide theoretical and practical instruction in the erection, setting to work, after sales service and maintenance of "Potterton" oil-fired and gas-fired boilers. A training film, which will be used during the course, was shown to an invited audience in London last week, and was followed by a practical demonstration at the training school.

DIE HEAD SCREWING MACHINE.—A single spindle "Tangential" die head screwing machine fitted with a 3in or 4in die head, which will thread bolts and pipes from ¼in. to 3in and ½in to 4in respectively, has been added to the range of machines made by Joshua Heap and Co., Ltd., Ashton-under-Lyne. These machines are fitted with a heavy-duty nine-speed all-geared headstock to suit the threading of all classes of material. The machine is fitted with a centrally mounted lead screw, which is necessary when screwing very coarse threads, which must be cut at two passes. Alternate lengths of bed can be supplied so that either 15in or 36in can be screwed at one setting of the vice.

YACHT MEASUREMENT.—On Thursday, October 10, Mr. D. Philips-Birt read a paper entitled "Some Problems of Yacht Measurement" before the Institution of Naval Architects. The paper gives contemporary European yacht measurement rules and goes on to consider the object of yacht measurement rules and to define the three elements of which the rules must be composed. A graph illustrates the basic formula for the International 5·5m class and also included are the International Cruiser-Racer Rule and the Royal Ocean Racing Club Rule. Length measurement and the speed reducing factor are discussed, as are also the principles of sail area measurement and the principal rig restrictions. This is followed by a section dealing with sail area measurement in contemporary rules and including a number of sail plans.

EXHIBITION OF WORK AT DOUNREAY.—We learn from the U.K. Atomic Energy Authority that an exhibition is to open at 10, Carlton House Terrace, London, S.W.1, on November 5, that will show some of the research and development work undertaken at Dounreay. Stages in the evolution of the fuel elements, the metallurgy and fabrication of the fuel, and canning and post-irradiation research on the elements will be demonstrated, we understand, as well as methods of reprocessing spent fuel to eliminate fission products and recover unused fuel and plutonium. Methods will be shown of solving the problems of corrosion, pumping and flow in the use of liquid sodium for the heat exchange circuit. Research managers from the various laboratories at Dounreay will be in attendance to answer questions at the exhibition, which will be open for three days from 10 a.m. to 8 p.m.

IMPROVING EFFICIENCY OF STEAM LOCOMOTIVES.—Investigations have been carried out by British Railways at Swindon into the application of double-draughting arrangements—double blast pipes and double chimney—to a standard "Class 4" mixed traffic 4–6–0 tender locomotive. Service tests with this modified locomotive were undertaken with particular regard to the lower grade fuel likely to become available in the future, and revealed that it was capable, with Blidworth Grade 2B coal, of fully maintaining a steaming rate of 22,500 lb per hour under all reasonable service conditions over a route with rising gradients of approximately 1 in 50. This represents more than a 50 per cent increase over the 14,000 lb per hour nominal rate for the "Class 4" engine and the modified engine also performed satisfactorily on certain fast services normally scheduled to be worked by "Class 5" locomotives. We are informed that as a result of these successful investigations it is proposed to fit all eighty locomotives of this class with the double-draughting arrangements and to experiment similarly with one of the B.R. standard 2–10–0 freight locomotives.

CENTENARY EDITION OF "VDI-ZEITSCHRIFT."—Last year the Verein Deutscher Ingenieure (V.D.I.) celebrated its centenary. This year, the *V.D.I.-Zeitschrift*, the journal of the Association of German Engineers, looks back on a hundred years of existence, and in order to mark the occasion, a special number (Vol. 99, 1957, No. 28, of October 1) has been published. Most of this large and well-produced edition is taken up by a review of technical and industrial progress during the last hundred years. In the section "Driving Forces of Technical Development," articles deal with the influence of pure science, the economic history of Germany as it changed from a mainly agricultural into an industrial state, the challenge of technology and its connection with science and the crafts. The present main aspects of the technical age are summarised in articles on the production of energy, materials, production engineering, metrology, automation, transport and communications. A third section discusses the problems of technical documentation and those of technical journalism. The centenary section concludes with a historical account of the *V.D.I. Journal*. In addition, the issue contains a number of articles under the collective heading of "Annual Review of Process Technology."

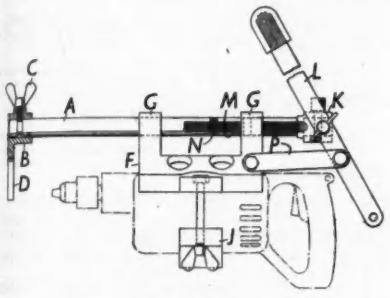
# British Patent Specifications

*When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.*

## WORKSHOP TOOLS AND APPLIANCES

**782,666.** July 15, 1953.—SUPPORTS FOR DRILLING AND SIMILAR APPARATUS, Cyril Rhodes Prince, 69, South Broomage Avenue, Larbert, Stirlingshire, Scotland, and formerly of 21, Wycliffe Street, Ossett, Yorkshire.

The invention relates to a support for a tool such as a drill, its object being to provide a support such that the tool can be easily used. The drawing is a diagrammatic side elevation of a tool support constructed in accordance with the invention. A bar *A* is provided at one end, with a projecting plate *B* which can be hooked to the workpiece and is retained on the bar by a wing nut *C*. The plate is cut away, as shown at *D*, to allow the drill to pass through. A



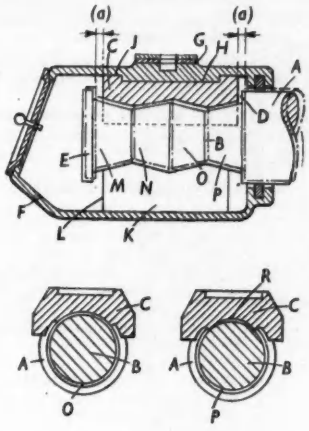

No. 782,666

clamp *F* is provided with two rearwardly projecting lugs *G* which are drilled so that the clamp is slidable on the bar. The clamp is provided with two diverging side-plates which engage the sides of the portable drill which is held by a clamping member *J*. At the end of the bar remote from the projecting plate is an adjustable bracket *K*. On the bracket *K* is pivoted a lever *L* and from the bracket a threaded spindle *M* extends parallel with the main support bar *A*. This spindle passes through a hole in one of the projections *G* so as to locate the drill relative to the lever bracket *K*. A nut *N* is carried on the bar *M* so that the movement of the bar *A* can be controlled. The lever *L* is pivoted to the bracket and a connecting piece *P* connects the lever *L* to the clamp *F*. The lever arrangement is such that if the drill is clamped in position and held in its normal working position, the lever will have to be pulled to exert pressure on the drill against the load of a return spring, not shown in the drawing. An alternative bench drill arrangement is also shown in the specification.—*September* 11, 1957.

## RAILWAY ENGINEERING

**782,733.** September 11, 1952.—RAILWAY AXLE AND LIKE BEARINGS, Seetru, Ltd., formerly Seetru Products, Ltd., 83, Stokes Croft, Bristol, 1.

The invention relates to railway axle and like bearings with bearing shell running surfaces extending over an arc of not more than 45 deg. from either side of the vertical axle centre plane. In known constructions of railway axle bearings, the axle stub or journal *A* of the axle *B* carries a bearing shell *C*, the running surface of which extends over the whole length of the stub, but only over a limited arc of contact on either side of the vertical central plane of the axle stub, e.g. over an angle of not more than 45 deg. The axle stub *A* joins the axle with a step *D* and on its free end has a flange *E*. The bearing housing *F* carries on top of its ceiling wall a boss *G* for the mounting of the leaf spring and it carries inside the housing a shallow boss *H*, preferably of rectangular shape. The bearing shell *C* is formed in its top surface *J* with a socket which engages the boss *H* of the axlebox ceiling wall so that it is horizontally fixed in all directions in relation to the bearing housing. Below the axle stub, the axlebox contains the lubricating oil sump *K* from which oil is applied to the axle stub surface by a wick packet *L*. The drawing shows that there is axial play of an amount (*a*) between the bearing shell *C* and the step *D* on the one end and flange *E* on the other. In order to achieve the desired lubricating effect, the running surface of the bearing shell and the axle stub are formed as four congruent cones *M*, *N*, *O* and *P*, displaced axially to each other and paired in mirrored relationship to each other. In the central position of the axle stub, shown in dotted lines, the running surfaces form a perfectly mating fit. If, however, the axle stub is displaced in one axial direction to the bearing shell, then one parallel pair of cones *M* and *O*, according to the left-hand lower view, are completely relieved of bearing shell load, whilst at the same time the other pair of cones *N* and *P* take the bearing pressure of the bearing shell. In this position, however, as a result of the axial displacement, the

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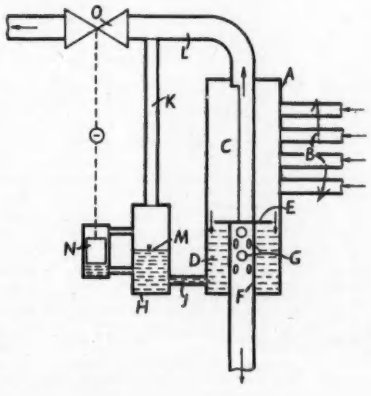
bearing shell rests on the axle stub only along the edges of the conical running surface as shown in the right-hand lower view, so that between the running surface of the bearing shell and the axle stub lubricating oil pads *R*, which are crescent-shaped in cross-section, are formed. These crescent-shaped lubricating oil pads *R* constantly change in cross-section, according to the axial movement of the axle stub, and are reduced in the central position of the axle stub, as shown line dotted, to the intrinsic thickness of the lubricating oil film. It is to be understood that the running surfaces of the bearing shell and the axle stub may also be sub-divided into six or more conical portions in mirrored pairs with or without an additional individual conical portion at one end.—*September* 11, 1957.

## STEAM GENERATORS

**782,782.** July 18, 1955.—FORCED FLOW, ONCE THROUGH STEAM GENERATORS, The Siemens-Schuckertwerke Aktiengesellschaft, Berlin, and 50, Werner-Von-Siemens-Strasse, 13*a* Erlangen, Germany.

The invention relates to a forced flow, once through steam generator, and is concerned with the steam and water separator arrangement. Referring to the drawing, a separator *A* is shown, *B* being the tubes of a

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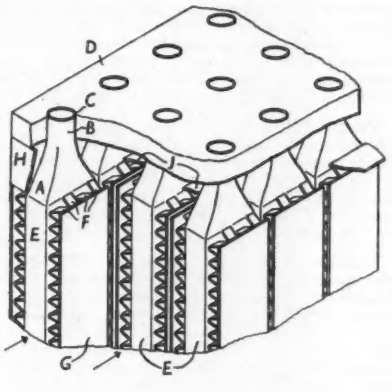
bank in which some of the water has already been converted into steam. The problem is to separate the steam and the water from each other, and to supply the water to the next tube bank via one or more down pipes and to pass the steam to the superheater. The separator is divided into two zones, a steam zone *C* and a water zone *D*. The insertion of a plate *E* is expedient but not necessary. The plate leaves an annular free space adjacent the wall of the separator, and the plate may also be provided with holes so that the incoming steam-water mixture cannot enter the water outlet pipe *F* directly. If desired, the tubes *B* may be made to lead in tangentially; the separation of steam and water is thereby facilitated. The pipe *F* has a number of staggered rows of holes *G* below the plate *E*, through which the separated water flows away, the discharge being regulated automatically. The greater the quantity of water produced and the higher the water level rises in consequence, the greater is the number of holes available for discharge. If it is desired to effect a regulation in dependence upon the quantity of water produced, an artificial water level may be provided by means of the following arrangement. A container *H* is connected in parallel with the separator and connected by a throttling pipe *J* to the water zone *D*, and by a pipeline *K* to a steam pipe *L*. In this way there is produced a water level *M* which is definite, since its height is determined by the static pressure in the water zone *D*. This water level *M* can now be used for control purposes. The quantity of water produced is a measure of the steam condition. If there is much water, this is a sign that the proportion of steam is declining, that is to say, less steam can be led off from the separator. Conversely, lowering of the water level shows that more steam is being produced and consequently more steam has to be led off. It is therefore possible, for example, by means of a float *N*, to control a valve *O* in the steam pipeline according to the existing ratio of steam to water.—*September* 11, 1957.

## HEAT EXCHANGERS

**782,525.** February 21, 1955.—NESTS OF TUBES FOR HEAT EXCHANGERS, Escher Wyss Aktiengesellschaft, Hardstrasse 319, Zurich, Switzerland.

The invention has as its aim to provide a heat exchanger which can be produced with minimum cost and in which a minimum amount of space is required for the heat exchange surfaces to be provided, while retaining the fundamental advantages of nests of tubes. According to the drawing, the nest of tubes consists of tubes *A* having end portions *B* or circular cross section, which are fitted into apertures *C* in a tube plate *D*. The surrounding heat exchanging medium acts on the tubes in cross-flow

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in the direction of the arrows. In the region in which the tubes are subjected to the action of this cross-current, they each comprise a portion *E* of rectangular cross-section. The substantially flat plane surfaces of the portion *E* of a tube which form part of the longitudinal sides of the rectangle are each lined by four corrugated metal strips *F* connected by soldering. A covering strip *G* is applied to the corrugations on the opposite side to the tube surface, and firmly connected so as to provide good thermal conductivity between the parts.

In the region in which the cross-section of the tubes changes from round to rectangular, cover plates *H* and *J* are provided to prevent any leakage of the heat-transmitting medium in this region. The corrugations of two adjacent strips *F* are arranged in staggered relationship to one another so as to give increased heat transfer at the corrugated strips. An arrangement for the production of the covering strips lined with the corrugated metal strips is also described in the specification.—*September* 11, 1957.

## Launches and Trial Trips

KOUNG SI, cargo ship; built by the Chantiers Navals de la Ciotat for the Messageries Maritimes; length between perpendiculars 488ft 4½in, breadth moulded 61ft 9in, depth to shelter deck 38ft 11in, load draught 25ft 7in, deadweight 8300 tons, hold capacity bale 530,000 cubic feet; Burmeister and Wain two-stroke, single-acting, mark 974K.T.F. 160 diesel engine, 8300 b.h.p. at 115 r.p.m., service speed 16 knots.—Trial, July.

FRIGORA, coaster; built by the Chantiers du Rhin for Kyvik of Hangesund; length overall 243ft 5½in, length between perpendiculars 216ft 7in, breadth moulded 33ft 6in, depth to shelter deck 20ft 8in, draught 12ft 8in (open shelter), 15ft (closed shelter), deadweight 1700 tons, speed 12 knots; L.A.K. mark MAU581A diesel engine, 1450 h.p. at 300 r.p.m.—Trial, July.

VILLE DE ROUEN, cargo liner; built by the Chantiers de la Seine Maritime for the Nouvelle Compagnie Havraise Peninsulaire; length overall 476ft 10½in, length between perpendiculars 445ft 9in, breadth moulded 60ft, depth to shelter deck 37ft 9in, draught 25ft 6in (open shelter), 27ft 9in (closed shelter), corresponding deadweights 9400 tons and 10,500 tons; speed 16·25 knots; five holds, one 50-ton, one 30-ton and twelve 10-ton derricks; Burmeister and Wain single-acting, two-stroke, mark 674VTBF 160 diesel engine, 7500 b.h.p., 115 r.p.m.—Trial, July.

FRANCOIS LE BRISE, cargo ship; built by the Ateliers et Chantiers de Bretagne for the Societe Navale Caennaise; length between perpendiculars 251ft 4in, breadth moulded 43ft 8in, depth to main deck 22ft 10in, draught loaded 19ft 4½in, deadweight 3400 tons, speed 11 knots; three holds, six 5-ton derricks; six-cylinder, supercharged, four-stroke M.A.N. diesel engine, mark G.6V.46.66., 1500 b.h.p. —Trial, July.

GALATEE, cargo ship; built by the Chantiers Reunis Loire-Normandie for the Societe Navale Caennaise; length overall 423ft 2in, length between perpendiculars 397ft 3½in, breadth moulded 49ft 11in, depth 28ft 6in, draught 21ft 0½in, deadweight 7000 tons, speed 13·25 knots; two S.E.M.T.-Pielstick, four-stroke, single-acting, supercharged diesel engines, 2560 h.p. at 420 r.p.m., each driving one shaft through hydraulic couplings and reduction gearing.—Trial, July.

PICARDY, cargo liner; built by Harland and Wolff, Ltd., at Belfast, for Royal Mail Lines, Ltd.; length overall 444ft 6in, length between perpendiculars 415ft, breadth moulded 58ft 6in, depth moulded to shelter deck 38ft 4in, gross tonnage 7300; three continuous decks, five holds, one 30-ton and fourteen derricks to lift up to 10 tons, electric winches; three 150kW diesel-driven generators; Harland and Wolff two-stroke, single-acting, opposed piston, diesel engine, six cylinders, 620mm diameter by 1870mm combined stroke, 118 r.p.m. Trial, August 22.

VENDEE, oil tanker; built by the Chantiers de l'Atlantique Penhoët-Loire for the Societe Francaise des Transports Petroliers; length overall 623ft 5½in, breadth moulded 84ft, depth 44ft 3½in, draught 33ft, deadweight 27,000 tons; Burmeister and Wain mark 974 VTBF 160 diesel engine, speed 16 knots.—Trial, August.

SALOUM, cargo ship; built by the Chantiers Navals de la Pallice for the Nederlands Franse Scheepvaart Maatschappij, Rotterdam; length overall 295ft 3½in, length between perpendiculars 265ft 9in, breadth moulded 41ft, depth to main deck 23ft 4in, draught 19ft 10in, deadweight 3434 tons (closed shelter deck), 2000 tons (open shelter deck); grain capacity 153,350 cubic feet; Deutz supercharged mark RVB.8.M.366 diesel engine, 1800 h.p. at 275 r.p.m.—Trial, August.

## Forthcoming Engagements

*Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME and PLACE at which the meeting is to be held should be clearly stated.*

### ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

*Sat., Oct.* 19.—OXFORD, READING AND DISTRICTS BRANCH: Regent's Park College, Pusey Street, Oxford, "The Work of the National Inspection Council for Electrical Installation Contracting," E. J. Sutton, 7 p.m.

*Wed., Oct.* 23.—NOTTINGHAM BRANCH: East Midlands Electricity Board's Showroom Theatre, Smithy Row, Nottingham, Annual Films Evening, 7.30 p.m.

*Thurs., Oct.* 24.—S. LONDON BRANCH: Greyhound Hotel, High Street, Croydon, "Electrical Installations in Ships," C. J. Penny, 8 p.m.

*Fri., Oct.* 25.—COVENTRY BRANCH: Visit to the English Electric Company, Rugby Works, 8 p.m.

*Tues., Oct.* 29.—LONDON NATIONAL LECTURE: Institution of Electrical Engineers, Savoy Place, London, W.C.2, Presidential Address, Sir Harold Bishop, 6.30 p.m.

### BRITISH COMPUTER SOCIETY

*Mon., Oct.* 21.—Senate House, University of London, Malet Street, London, W.C.1, Opening Meeting, "The Machine's-Eye View," D. R. Hartree, 6.15 p.m.

*Wed., Oct.* 23.—BUSINESS GROUP: Great Hall, Northampton College of Advanced Technology, St. John Street, London, E.C.1, General Meeting, 3 p.m.

### ENGINEERING METROLOGY ASSOCIATION

*Thurs., Oct.* 24.—Northampton College of Advanced Technology, St. John Street, London, E.C.1, "Precision Length Measurement in Australia," P. Holmes, 7 p.m.

### ILLUMINATING ENGINEERING SOCIETY

*Mon., Oct.* 21.—BATH AND BRISTOL CENTRE: Royal Hotel, Bristol, "Lighting as an Effective Aid to Architecture," H. E. Bellchambers, 7 p.m.

*Tues., Oct.* 22.—GLOUCESTER AND CHELTENHAM CENTRE: Fleece Hotel, Westgate Street, Gloucester, "Home Lighting," 6.30 p.m.

*Fri., Oct.* 25.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Horticultural Lighting," A. W. Gray, 6 p.m.

### INSTITUTE OF BRITISH FOUNDRYMEN

*Wed., Oct.* 23.—LONDON BRANCH: Constitutional Club, Northumberland Avenue, London, W.C.2, "Aids to Automation," J. A. Hufton, 7.30 p.m.

### INSTITUTE OF MARINE ENGINEERS

*Mon., Oct.* 21.—W. OF ENGLAND SECTION: Grand Hotel, Bristol, "Elimination of Torsional Vibration in Diesel Engine Transmission Systems by Flexible Coupling Incorporating Forced Viscous Damping, also Considered in Conjunction with Engine Isolation," G. Hallewell, 7.30 p.m.

*Wed., Oct.* 23.—SCOTTISH SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "Survey of Ships," R. E. Knowles, 7.30 p.m.

*Thurs., Oct.* 24.—S. WALES SECTION: South Wales Institute of Engineers, Park Place, Cardiff, Joint Meeting with the Institute of Welding, "Welding Metals by Pressure," A. R. E. Singer 7 p.m.

### INSTITUTE OF NAVIGATION

*Wed., Oct.* 23.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Off the Beaten Track," 2.15 p.m.

### INSTITUTE OF PETROLEUM

*Wed., Nov.* 6.—26, Portland Place, London, W.1, "The Impact of Cyclical Fluctuations on Fuel Oil Demand," G. Chandler and D. W. Lindsell, 5.30 p.m.

### INSTITUTE OF PHYSICS

*To-day, Oct.* 18.—S. WALES BRANCH: Physics Department, University College of South Wales and Monmouthshire, Cardiff, "Structural and Physical Properties of Alloys," H. Jones 5.15 p.m. ★ NON DESTRUCTIVE TESTING GROUP: 47, Belgrave Square, London, S.W.1, "Nuclear Magnetic and Paramagnetic Resonance," L. E. Drain, 6 p.m.

### INSTITUTE OF ROAD TRANSPORT ENGINEERS

*Mon., Oct.* 21.—SCOTTISH CENTRE: North British Hotel, Edinburgh, "Various Trends in Machining and Inspection Methods Concerning the Manufacture of Heavy Commercial Vehicles," R. P. Chilton, 7.30 p.m.

### INSTITUTION OF CHEMICAL ENGINEERS

*Sat., Oct.* 19.—MIDLANDS BRANCH: Lecture Theatre, Acetate and Synthetic Fibres Laboratory, Lockhurst Lane, Coventry, "The Use of Digital Computers in Planning Plant Operations," D. A. Caplin, 3 p.m.

### INSTITUTION OF CIVIL ENGINEERS

*Wed., Oct.* 23.—N.W. ASSOCIATION: Joint meeting with the Liverpool Engineering Society, 9, The Temple, 24, Dale Street, Liverpool, "The Construction of a Modern Oil Refinery," P. G. Hall, 6.30 p.m.

### INSTITUTION OF ELECTRICAL ENGINEERS

*To-day, Oct.* 18.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "The Architectural Features of Electrical Engineering Laboratories," opened by H. E. Dance and P. F. Soper, 6 p.m.

*Mon., Oct.* 21.—MERSEY AND N. WALES CENTRE: Royal Institute, Colquitt Street, Liverpool, "Brushless Variable-Speed Induction Motors," F. C. Williams, E. R. Laithwaite and L. S. Piggott, 6.30 p.m. ★ N.E. RADIO AND MEASUREMENTS GROUP: King's College, Newcastle upon Tyne, Chairman's Address, W. Gray, 6.15 p.m. ★ S. MIDLAND SUPPLY AND UTILIZATION GROUP: College of Technology, Birmingham, "Earthing of Low and Medium-Voltage Distribution Systems and Equipment," F. Mather, 6 p.m. ★ WESTERN SUPPLY GROUP: South Wales Institute of Engineers, Park Place, Cardiff, Chairman's Address, C. W. Priest, 6 p.m. ★ READING BRANCH: George Hotel, King Street, Reading, "An Historical Survey of the Development of Switchgear," A. Abbott, 7.15 p.m.

*Tues., Oct.* 22.—MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2, "The Measurement of High Voltages with Indicating or Recording Instruments," G. W. Bowdler, 5.30 p.m. ★ E. MIDLAND CENTRE: College of Arts and Crafts, Waverley Street, Nottingham, "Mechanical Strength of Power Transformers in Service," E. T. Norris, 6.30 p.m. ★ E. ANGLIAN SUB-CENTRE: University Engineering Laboratory, Trumpington Street, Cambridge, "Engineering Education in the Soviet Union," G. S. C. Lucas, 6.30 p.m. ★ N.W. MEASUREMENT AND CONTROL GROUP: Engineers' Club, 17, Albert Square, Manchester, "A Deep Electrolytic Tank for the Solution of Two and Three-Dimensional Field Problems in Engineering," E. R. Hartill, J. G. McQueen and P. N. Robson, 6.15 p.m. ★ S. MIDLAND CENTRE, EDUCATION DISCUSSION CIRCLE: College of Technology, Gosta Green, Birmingham, Discussion on "Co-ordination of the Initial Courses for Engineering Students," to be opened by D. G. Christopherson, 7.15 p.m. ★ N. MIDLAND GRADUATE AND STUDENT SECTION: C.E.A. Offices, 1, Whitehall Road, Leeds, "Harmonics in Discharge Tube Circuits," W. Waring and J. Lofts, 7 p.m.

*Wed., Oct.* 23.—SUPPLY SECTION: Savoy Place, London, W.C.2, Chairman's Address, "Too Much and Too Little," M. G. Say, 5.30 p.m. ★ RUGBY SUB-CENTRE: Rugby College of Technology and Arts, Rugby, "Electricity in Agriculture," J. T. Taylor, 6.30 p.m.

*Thurs., Oct.* 24.—UTILIZATION SECTION: Savoy Place, London, W.C.2, "The Post-War Electrification of the Polish State Railways," J. Podoski, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION, DISTRICT MEETING: Medway College of Technology, Chatham, Kent, Repeat of Chairman's Address, F. L. Fielding, 7 p.m.

*Fri., Oct.* 15.—SOUTHERN CENTRE: South Dorset Technical College, Weymouth, "The Transatlantic Telephone Cable," R. J. Halsey, 6.30 p.m.

### INSTITUTION OF ENGINEERING DESIGNERS

*Thurs., Oct.* 24.—38, Portland Place, London, W.3, "Drawing, Imagery and Design," P. J. Booker, 7p.m.

*Sat., Oct.* 26.—N.E. BRANCH: Visit to Huwood Mining Machinery, Ltd., Team Valley Trading Estate, 9.30 a.m.

### INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

*Tues., Oct.* 22.—39, Elmbank Crescent, Glasgow, "The Strength and Stiffness of Scalloped Stiffeners Determined by Full-Scale Tests at Glengarnock," K. V. Taylor and M. N. Parker, 6.30 p.m.

### INSTITUTION OF ENGINEERS IN CHARGE

*Fri., Oct.* 25.—Caxton Hall, Caxton Street, Westminster, London, S.W.1, Presidential Address, Sir Harold Roxbee Cox, 6.30 p.m.

### INSTITUTION OF LOCOMOTIVE ENGINEERS

*Wed., Oct.* 23.—GENERAL MEETING: Institution of Mechanical Engineers, 1, Birdcage Walk, Westminster, London, S.W.1, "Modern Battery Railcars," G. Wilke, 5.30 p.m.

### INSTITUTION OF MECHANICAL ENGINEERS

*To-day, Oct.* 18.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, Presidential Address, Sir George Nelson, 6 p.m. ★ SCOTTISH BRANCH: Technical College, Dundee, "The Steam Catapult," C. C. Mitchell and Q. H. Paterson, 7.30 p.m.

*Mon., Oct.* 21.—MIDLAND GRADUATE SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Highlights in the History of Mechanical Engineering," E. G. Sterland, 6.45 p.m.

*Tues., Oct.* 22.—S. WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, "Mechanical Breathing Machines," G. T. Smith-Clarke, 6 p.m. ★ LONDON GRADUATE SECTION: Visit to Pitter Gauge and Precision Tool Company, Ltd., Market Street, London, S.E.18, 2.30 p.m. ★ LONDON GRADUATE SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Is Britain Lagging in the Design of the Small Car?" 6.30 p.m.

*Wed., Oct.* 23.—E. MIDLANDS BRANCH: Conference Room, Central Electricity Authority Generating Station, Peterborough, "Applications of Radioisotopes to Engineering," C. G. Clayton, 7.30 p.m.

*Thurs., Oct.* 24.—LUBRICATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Diagnosis of Causes of Ball and Roller Bearing Lubrication Failures," 6.45 p.m. ★ N.W. GRADUATE SECTION: Engineers' Club, Albert Square, Manchester, Technical Film Show, 7 p.m.

*Fri., Oct.* 25.—GENERAL MEETING IN CONJUNCTION WITH THE APPLIED MECHANICS GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, "Dynamic Stresses in the Teeth of Spur Gears," S. L. Harris, 6 p.m.

### INSTITUTION OF PRODUCTION ENGINEERS

*Mon., Oct.* 21.—COVENTRY BRANCH: Craven Arms, High Street, Coventry, "Russian Machine Tool Industry," Norman Stubbs and Peter Trippe, 7.15 p.m. ★ SHEFFIELD GRADUATE BRANCH: Daniel Doncaster and Sons, Ltd., Penistone Road, Sheffield, "Drop Stamping and Forging," 6.30 p.m.

*Wed., Oct.* 23.—WORCESTER BRANCH: Cadena Cafe, Worcester, "High-Speed Presswork," J. A. Grainger, 7.30 p.m.

*Thurs., Oct.* 24.—LUTON GRADUATE BRANCH: Town Hall, Luton, "Production Control by Punched Cards," J. F. A. Bryen, 7.30 p.m.

*Fri., Oct.* 25.—CARDIFF BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, "Management and Productivity," W. E. Gowers, 7 p.m.

*Sat., Oct.* 26.—NEWCASTLE UPON TYNE GRADUATE SECTION: Visit to Victor Products, Ltd., Church Bank, Wallsend upon Tyne, 10 a.m.

### INSTITUTION OF WORKS MANAGERS

*Tues., Oct.* 22.—LONDON BRANCH: Royal Society of Arts, John Adam Street, Strand, London, W.C.2, Annual General Meeting, followed by "The Trade Unions and Productivity," E. Fletcher, 7 p.m. ★ MERSEYSIDE BRANCH: Adelphi Hotel, Mersey, "Incentives for Maintenance Work," C. C. Moss, 6.30 p.m. ★ LANCASTER GROUP: Royal King's Arms Hotel, Lancaster, "Work Planning by Computers," C. M. Berners-Lee, 7.30 p.m.

### JUNIOR INSTITUTION OF ENGINEERS

*To-day, Oct.* 18.—INFORMAL MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Sub-Standard Films," W. C. C. Ball, 7 p.m.

*Fri., Oct.* 25.—ORDINARY MEETING: Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "Rocks and Sands," S. J. Crispin, 7 p.m.

### MANCHESTER GEOLOGICAL AND MINING SOCIETY

*Thurs., Oct.* 24.—Wigan and District Mining and Technical College, Wigan, Annual General Meeting, 3.30 p.m.

### NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

*To-day. Oct.* 18.—Literary and Philosophical Society, Newcastle upon Tyne, Film on M.V. "Bergensfjord," Opening General Meeting, 6.15 p.m.

### PLASTICS INSTITUTE

*To-day, Oct.* 18.—MIDLANDS SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, "Polyesters," J. R. Stevenson, A. de Pani and J. D. Mundella, 6.30 p.m.

### ROYAL METEOROLOGICAL SOCIETY

*To-day, Oct.* 18.—MANCHESTER CENTRE: The University, Manchester, "Winds in the Upper Atmosphere," J. S. Greenhow, 5.45 p.m.

*Fri., Oct.* 25.—SCOTTISH CENTRE: Department of Natural Philosophy, Drummond Street, Edinburgh, Talk on "Royal Society Base, Halley Bay, Antarctica," S. Evans, 5 p.m.

### SHEFFIELD METALLURGICAL ASSOCIATION

*Tues., Oct.* 22.—B.I.S.R.A., Hoyle Street, Sheffield, "The Russian Iron and Steel Industry," R. Wilcox, 7 p.m.

### SOCIETY OF CHEMICAL INDUSTRY

*Mon., Oct.* 21.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Accelerated Tests of Metal Coatings: "Sulphur Dioxide Test," "Acetic Salt/Acid Spray," J. Edwards and J. H. Hooper, 6.30 p.m.

## Advanced Engineering Courses

**Elements of Law Relating to Civil and Mechanical Engineering.** By F. MAURICE DRAKE. BATTERSEA COLLEGE OF TECHNOLOGY, DEPARTMENT OF CIVIL AND MECHANICAL ENGINEERING, Battersea Park Road, London, S.W.11. A course of five lectures on Tuesday evenings from 6.45 to 8.45 p.m., commencing on October 29. Fee 10s.

**Aero Engine Design.** POWER JETS (RESEARCH AND DEVELOPMENT), Ltd., THE SCHOOL OF GAS TURBINE TECHNOLOGY, Farnborough Place, Farnborough, Hampshire. Course No. 136. November 4 to 22. Fee 60 guineas.